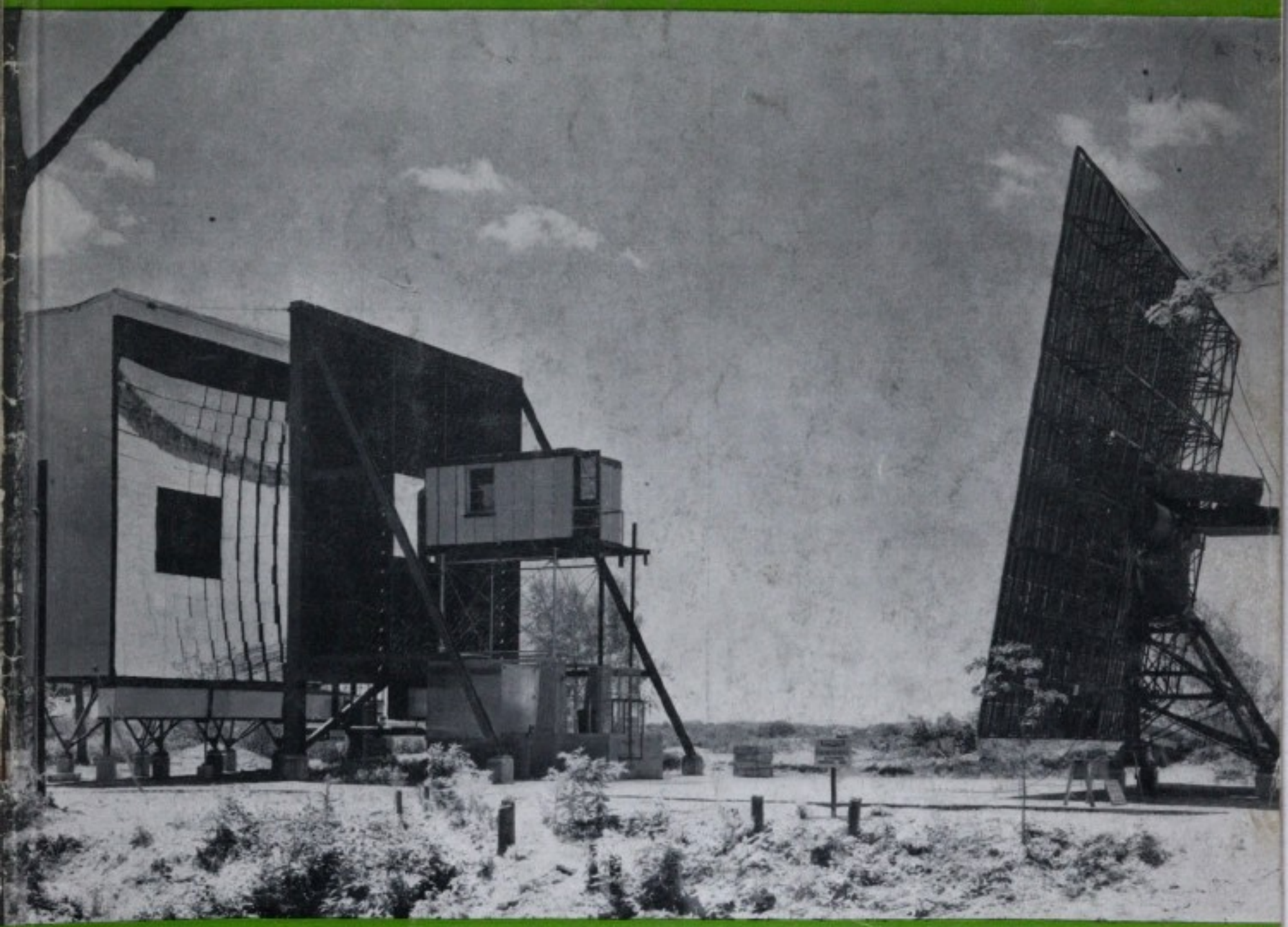
Sky and TELESCOPE



U. S. Army solar furnace

In This Issue:

The Largest American Solar Furnace

World's Astronomers Meet in Moscow

Boston's Planetarium Opens

American Astronomers Report

The Chemical Composition and Ages of Stars

The New IAU Nomenclature for Mars

Among Southern Galaxies — X

Stars for November

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Vol. XVIII, No. 1

NOVEMBER, 1958

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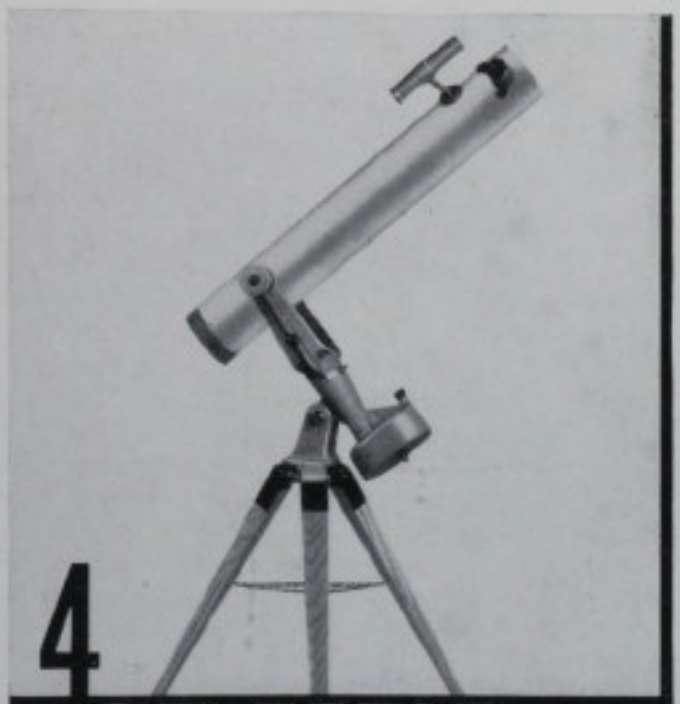

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Sky and TELESCOPE

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Vol. XVIII, No. 1 NOVEMBER, 1958

CONTENTS

COVER: The nation's largest solar furnace, which began operation on September 30th at the U. S. Army's Quartermaster Research and Engineering Center, Natick, Massachusetts. Built for testing Army materials that will be exposed to atomic explosions, the furnace can develop temperatures near 5,000° Fahrenheit. The 36-foot-high heliostat at the right is 96 feet from the many-mirrored concentrator at the left. U. S. Army photograph. (See page 4.)

SUBMARINE AND SPACE MEDICINE SYMPOSIUM 3
THE LARGEST AMERICAN SOLAR FURNACE 4
WORLD'S ASTRONOMERS MEET IN MOSCOW — Bart J. Bok 7
BOSTON'S PLANETARIUM OPENS — John Patterson 13
THE CHEMICAL COMPOSITION AND AGES OF STARS — Otto Struve 17
AMERICAN ASTRONOMERS REPORT 20
THE NEW IAU NOMENCLATURE FOR MARS — Joseph Ashbrook 23
AMONG SOUTHERN GALAXIES – X 26
MAN'S FARTHEST STEP INTO SPACE ..... Center Supplement

AMATEUR ASTRONOMERS 16
BOOKS AND THE SKY 39
Of Stars and Men
Planets, Stars and Space
Frontiers in Science
The Black Cloud
CELESTIAL CALENDAR 54
GLEANINGS FOR ATM's 47
Balancing the Tube of a Reflecting Telescope
NEWS NOTES 22
OBSERVER'S PAGE 30
Early Observations of Mars
Deep-Sky Wonders
Amateur Photographs of Mars
OBSERVING THE SATELLITES 28
QUESTIONS 22
STARS FOR NOVEMBER 57

FEATURE PICTURE: The barred spiral NGC 1365, in the southern constellation Fornax, photographed with the Radcliffe Observatory's 74-inch reflector, on October 23, 1954. This picture is from the Cape Photographic Atlas of Southern Galaxies, compiled by the Royal Observatory, Cape of Good Hope, Union of South Africa. 27

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Submarine and Space Medicine Symposium

TWO HUNDRED scientists, invited from nine countries, attended the first gathering of its kind at the U. S. Submarine Base, New London, Connecticut, on September 8-12. The first international symposium on submarine and space medicine was sponsored by the American Institute of Biological Sciences and the Department of Defense.

The meeting's purpose was to stimulate physiological research dealing with interplanetary travel. Its participants wished for closer working relations with scientists in other fields. While agreeing that spaceflight is possible, they disagreed with engineers who state that all required information can be relayed to the earth from space by unmanned satellites.

It is apparent that man must take his earth environment into space by sealed-cabin flight. Many of the physiological problems are those of travel by submarine, but with additional complications. The Navy showed movies of an aluminum sphere of the sealed-cabin type used to carry one man to altitudes of about 90,000 feet for special studies. It was designed over 10 years ago.

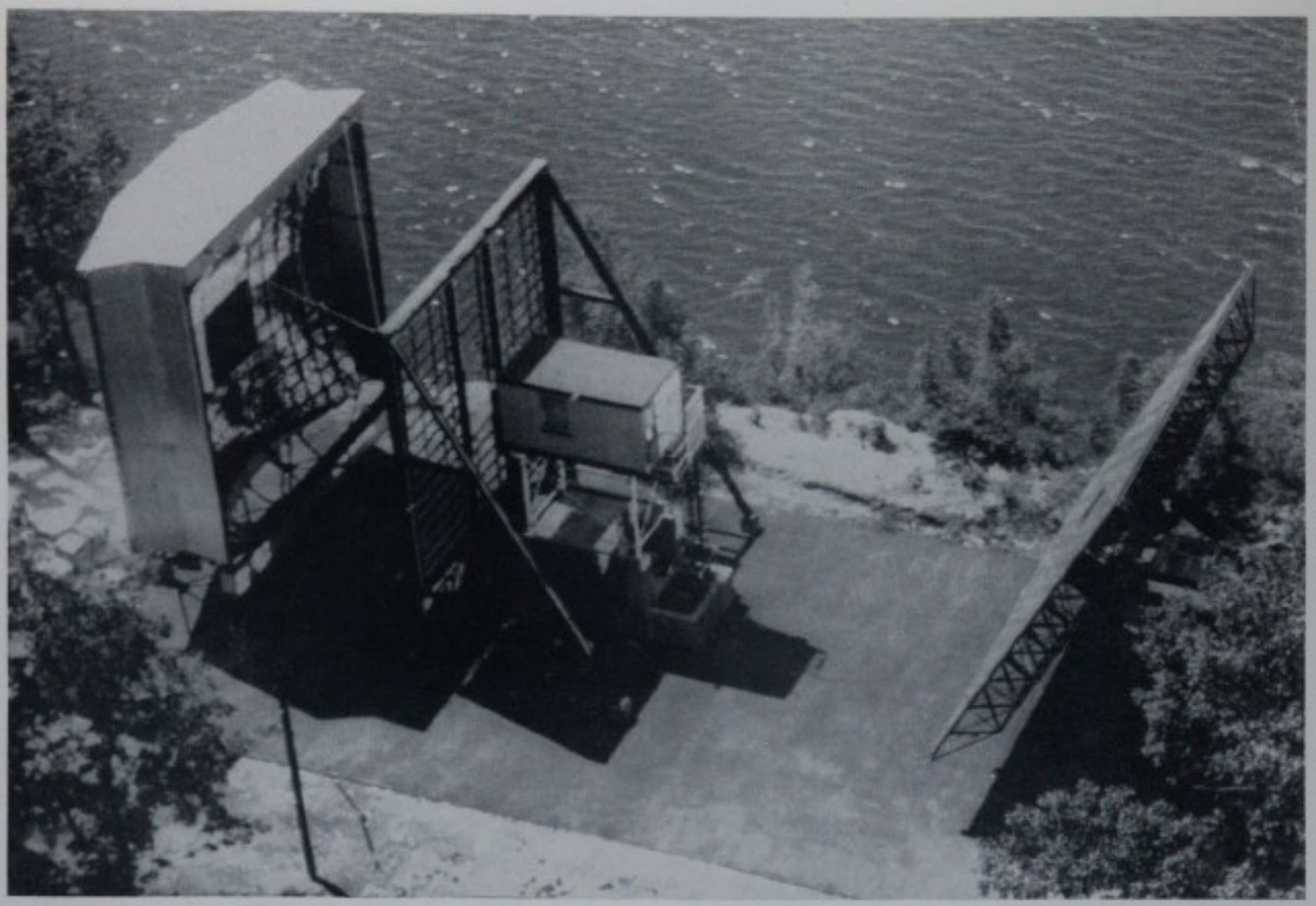
Scores of research reports were presented, on topics including the effect of rotation of the earth upon a subject's metabolism and performance of work, and effects of spaceflight on circulation of the blood to the heart, lungs, and brain. Lt. Col. David G. Simons told about his flight of August, 1957, into the stratosphere, when a height of over 100,000 feet was reached. He described how he experienced the "breakoff" phenomenon, a peculiar feeling of well-being and buoyancy, in which the space traveler has a strong disinclination to return to earth; similar partial separation occurs among persons pursuing certain atavistic forms of meditation. The breakoff is not due to the toxic effect of breathing too much carbon dioxide.

Both the submariners and astronauts were concerned with the toxicological problems of confined spaces – carbon-monoxide and ozone poisoning, and the effects of condensation droplets.

A new strain of fast-multiplying algae was described that can supply oxygen continuously for one man in spaceflight. The required volume for both the growing tank and the light source necessary for propagation of the algae is less than five cubic feet.

Participants in the conference gained a keen awareness that vast changes in man's experience of life are in the making, even more profound than those of Renaissance man.

HOWARD LASKEY, M.D.
Carolina, R. I.



A high-angle view of the U. S. Army's new solar furnace, located on the shore of Lake Cochituate, Massachusetts. From the steerable heliostat, at the right, sunlight is reflected to the concentrator at the left, which focuses it into the test chamber at center. The attenuator is almost open here, while in the view on the front cover its shutters are almost closed.

The Largest American Solar Furnace

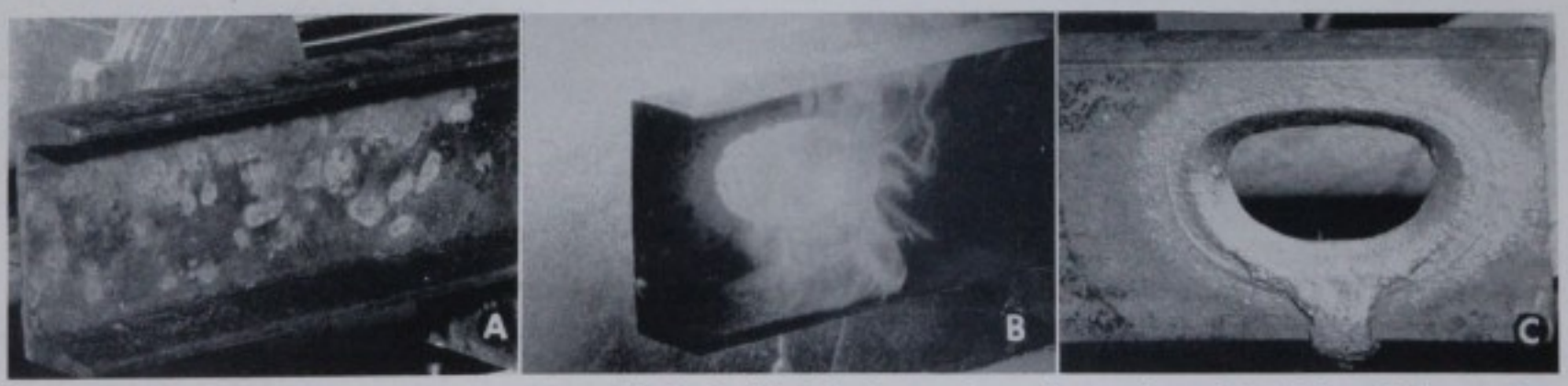
MANY useful purposes can be served by solar furnaces — from cooking food to testing materials intended to withstand an atomic blast. The latter is the reason for the building of America's largest solar furnace, at Natick, Massachusetts, on the wooded shore of Lake Cochituate. It is part of the U. S. Army's Quartermaster Research and Engineering Center.

This is the same instrument whose preliminary plans were described in *Sky and Telescope* for May, 1957, page 332. Its completion was celebrated by a formal dedication on September 30, 1958, followed by a two-day symposium at which experts discussed many aspects of the utilization of energy from the sun.

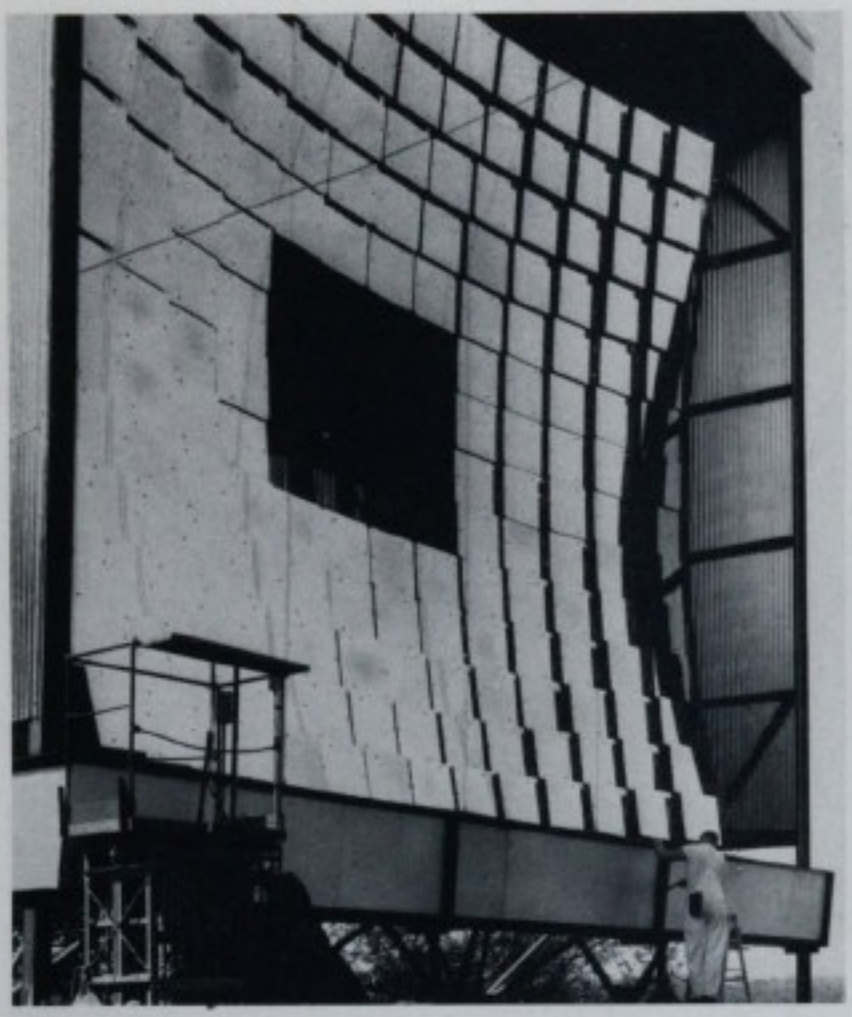
Located 17 miles west of Boston, the $275,000 apparatus occupies a ground area 125 by 40 feet. It is the first large furnace of the focusing type to utilize an effective focal ratio of less than one, and will furnish much valuable information on the effects of high-intensity thermal radiation on materials.

The Natick installation is not a furnace in the ordinary sense; it is not a means for maintaining a sustained high temperature, but instead provides short pulses of extremely intense heat radiation — similar to those of atomic-bomb blasts. Thus the furnace is a convenient and economical device for testing Army protective materials before actual field trials.

The Quartermaster Corps engineers



Photographs taken during an operational test with the Natick solar furnace show a heavy piece of iron before, during, and after being subjected to the four-inch-wide beam of concentrated solar radiation, which burned through the ¼-inch-thick metal in only one second.



Above: The 36-foot-high heliostat, which can follow the sun in altitude and azimuth, with its 355 plate-glass mirrors.

Left: A workman at bottom right is dwarfed by the concentrator's 180 concave mirrors. They form an over-all effective surface that acts as a paraboloid.

found the sun to be the most suitable available source of intense thermal radiation. Other sources, such as gas flames or electric arcs, are either too cool or generate heat over too small an area. With the adopted design, a blast of heat reaching nearly 5,000° Fahrenheit can be obtained over a circle four inches in diameter.

There are four main parts to the solar furnace: heliostat, attenuator, concentrator, and test chamber. Sunlight is first collected by the heliostat, an array of 355 mirrors, each two-feet square and $\frac{1}{4}$-inch thick, placed so they act as a single large plane mirror. This array is square rather than circular, as in the case of the large furnace at Montlouis in France.

The aluminum heliostat framework, 36 feet high and 40 feet wide, can track the sun both in altitude and azimuth. A similar mounting design has been used by the builders, D. S. Kennedy and Co., for some of their radio telescopes and radar antennas. On the longest day of the year, up to eight hours of operation are possible.

From the heliostat sunlight passes through the attenuator, a Venetian-blind arrangement to control the amount of radiation reaching the concentrator. The 17 shutter slats close automatically in case of power failure, incorrect tracking, or other emergency.

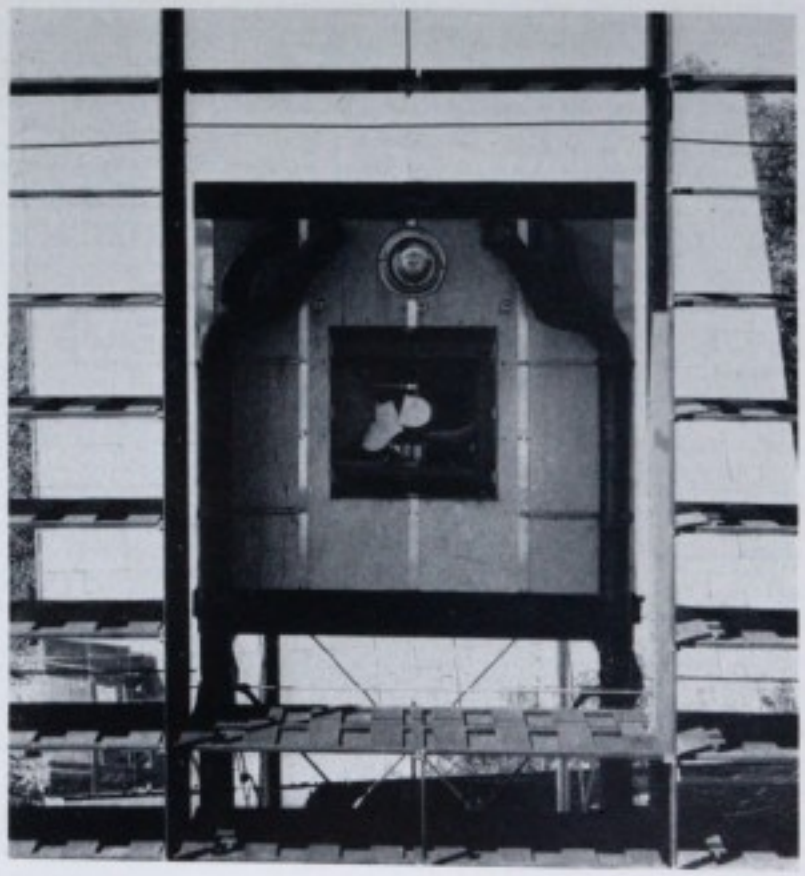
Next the solar beam strikes the concentrator, a concave spherical frame supporting 180 mirrors, also two-feet square and $\frac{1}{4}$-inch in thickness. These concave mirrors are spherical, of 35.8 feet focal length. Their effective area is 710 square feet.

Not only is it much cheaper to use such a mosaic of many small mirrors than it is to make a single surface, but the mirrors can be adjusted individually to minimize aberrations. Thus, at the focus of the concentrator the solar image is about four inches in diameter, with a uniform intensity of about 90 calories per square centimeter each second, corresponding to a total power of 27 kilowatts.

The test chamber has an eight-foot square face and is 16 feet long. Inside are holders for samples, the heliostat and attenuator controls, and measuring devices to record test results. Just before a test begins, a water-cooled protective shutter is opened. The exposure of the sample is provided by a second, high-speed shutter, also water-cooled, which can be opened for as little as 0.1 second.

The lakeside site offers a clear western horizon, and the surrounding woods give good protection from winds, though the installation is designed to withstand hurricane velocities.

From the technological viewpoint, perhaps the most significant feature of the Natick furnace is the effective use of small, mass-produced mirrors for concentrating sunlight, a method that will facilitate the future large-scale exploitation of solar energy.



The eight-foot-high test chamber, mounted behind the opening in the shuttered attenuator. Seen here, in the end facing the concentrator, is the aperture through which the intense beam enters. In the background, part of the heliostat may be seen through the Venetian-blind-type vanes of the attenuator, opened here to their full horizontal position. All photographs with this article are by the U. S. Army.

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AUGUST
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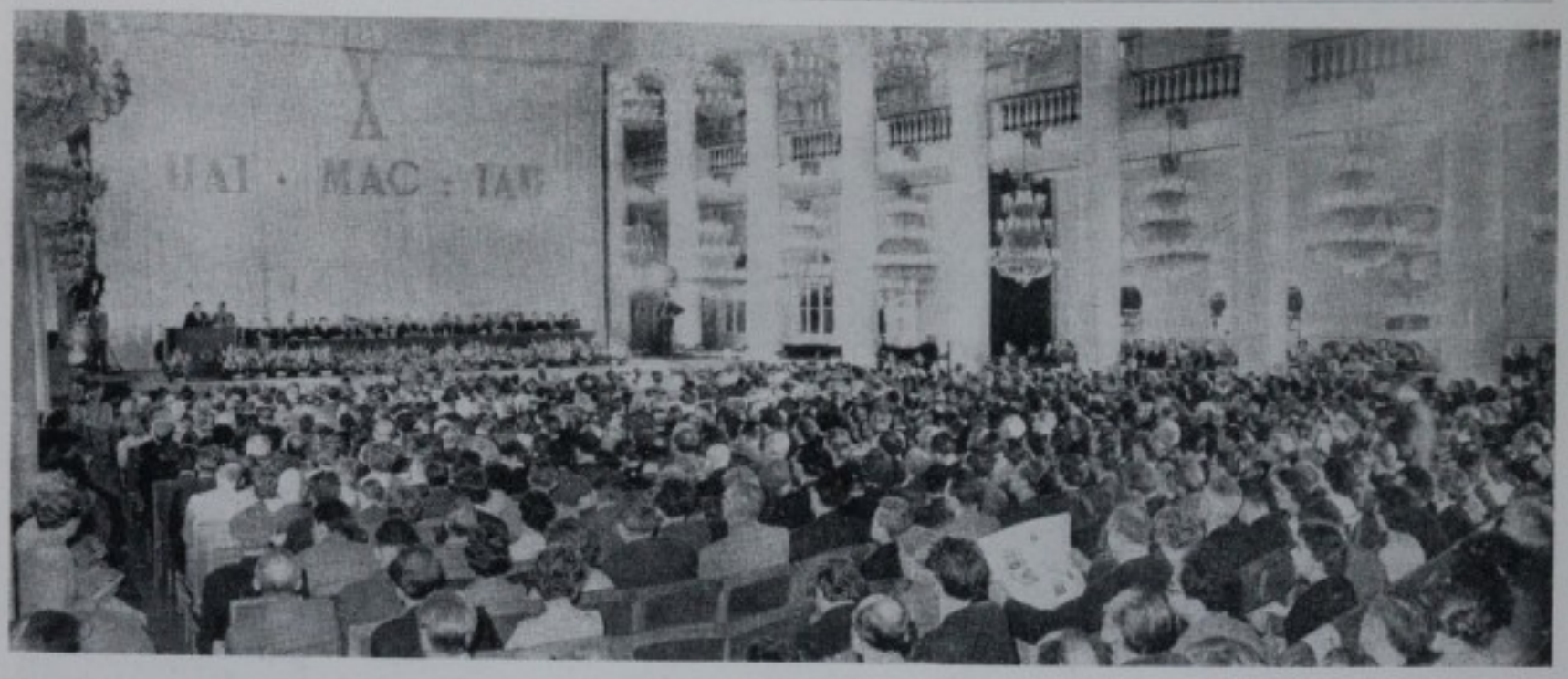
1958

№ 2

Газета организационного комитета 10-го съезда Международного Астрономического Союза

Gazette du Comité d'Organisation de la X-me Assemblée Générale de l'Union Astronomique Internationale

Newspaper of the Organizing Committee for the Xth General Assembly of the International Astronomical Union



Торжественное открытие 10-го съезда Международного Астрономического Союза

Inauguration solennelle de la X-e Assemblée générale de l'Union Astronomique Internationale

Grand Opening of the Xth General Assembly of the International Astronomical Union

12 августа состоялось торжественное открытие съезда в Колонном зале Дома союзов. В зале присутствуют делегации из 35 стран.

7 часов вечера. Глава советской делегации председатель Астрономического совета Академии наук СССР профессор **А. А. Михайлов** объявляет X съезд открытым.

На трибуне — Заместитель Председателя Совета Министров СССР **А. Н. Косыгин**. По поручению Советского Правительства он приветствует участников съезда и гостей.

— Правительство Советского Союза,— сказал А. Н. Косыгин,— придает большое значение международному сотрудничеству ученых.

А. Н. Косыгин от имени Советского Правительства пожелал участникам съезда плодотворной работы и выразил уверенность в том, что их совместная деятельность будет способствовать развитию дружеских отношений между учеными всех стран, укреплению мира во всем мире.

Грандиозным успехом астрономии и, в первую очередь, советской астрономии посвящена приветственная речь Президента Международного астрономического союза профессора **А. Данжона.**

— Нынешний Международный съезд,— говорит он,— происходит меньше чем через год после грандиозного эксперимента — запуска первого советского искусственного спутника Земли. Эта дата отныне вписана золотыми буквами в число величих событий мировой истории.

Академик **А. В. Топчиев**, вице-президент Академии наук СССР, в своем приветствии главное внимание уделяет развитию международных научных связей. Контакты и связи деятелей советской науки с зарубежными учеными растут с каждым годом.

К своим советским и зарубежным коллегам обращается известный астроном академик **В. А. Амбарцумян.** Он говорит, что астрономия своими успехами в весьма значительной части обязана международному научному сотрудничеству ученых разных стран.

По мнению академика Амбарцумяна, ученые подошли сейчас к такому этапу развития астрофизики, когда перед ними раскрываются новые свойства материи, которые до сих пор не могли быть вскрыты на основе экспериментов в земных лабораториях.

Торжественный вечер закончился большим вокально-симфоническим концертом.

* * *

Вчера 13 августа в 9 часов утра в Актовом зале Московского Университета открылось пленарное заседание X съезда МАС. Открывая заседание, Президент МАС проф. А. Данжон предложил почтить вставанием память скончавшихся после IX съезда 28 членов Союза.

На заседании оглашено приветственное письмо бывшего Президента МАС О. Струве. Принят текст ответной телеграммы.

Заслушан отчет Генерального секретаря МАС П. Остерхофа.

В 2 часа дня началась Объединенная дискуссия по астрономическим наблюдениям с искусственных спутников Земли, ракет и баллонов.

Одновременно происходили заседания Финансового комитета и Объединенной комиссии по спектроскопии.

The XIth General Assembly of the International Astronomical Union opened August 12 in the Column Hall of the House of Trade Unions, Moscow. Present at the opening were delegations from 35 countries.

7:00 PM. The Head of the Soviet delegation, Chairman of the Astronomical Council of the Academy of Sciences of the USSR, Professor **A. A. Mikhailov** announces the opening of the XIth General Assembly.

A. N. Kossigin, Vice Chairman of the Soviet of Ministers of the USSR, mounts the rostrum. On behalf of the Soviet Government he greets the participants and guests of the General Assembly.

— The Government of the Soviet Union,—said A. N. Kossigin,—attaches great importance to the international co-operation of scientists.

On behalf of the Soviet Government A. N. Kossigin wishes the participants of the General Assembly fruitful results of their work and expresses the conviction that their joint activity will be an aid in both the development of friendly relations among scientists of all countries and the strengthening of peace throughout the world.

The speech of welcome of the President of the International Astronomical Union, Professor **A. Danjon** was inspired by the grandiose successes achieved by astronomy, and especially by Soviet astronomy. The present International General Assembly is held less than one year from the epoch-making experiment—the launching of the first Soviet artificial Sputnik of the Earth, the date, which is inscribed in Golden Letters in the annals of history.

Academician **A. V. Topchiev**, Vice President of the Academy of Sciences of the USSR, in his speech of greetings invited the attention of the delegates chiefly to the consideration of the development of international scientific connections.

Contacts and connections of Soviet men of science with their foreign colleagues are growing from year to year.

The well known astronomer, the academician **V. A. Ambartsumian** greets his Soviet and foreign colleagues. He said that the successes of astronomy were to a large extent made possible by the international scientific cooperation of scientists of many countries.

In the opinion of the academician V. A. Ambartsumian, the scientists have now reached such a stage in the development of astrophysics, when we stand before the discovery of such new properties of matter, which up to now could not have been revealed on the basis of experiments made in terrestrial laboratories.

The Grand Evening was concluded with a large Vocal-Symphonic Concert.

* * *

The plenary session of the XIth General Assembly of the International Astronomical Union opened yesterday, August 13, at 9:00 AM, at the Moscow University.

Opening the session, Professor Danjon proposed to honour the memory of 28 deceased members of the IAU.

A letter of former president Struve was read. He sent his greetings and best wishes for a successful meeting.

General Secretary Oosterhoff made a report.

At 2 o'clock began the discussion on sputniks, rockets and balloons.

L'ouverture solennelle du X-ème Congrès Astronomique a eu lieu le 12 août dans la Salle des Colonnes, en présence des délégués de 35 pays.

Sept heures du soir. Le chef de la délégation Soviétique président du Conseil Astronomique de l'Académie des Sciences de l'URSS professeur **A. A. Mikhailov** annonce l'inauguration de la X-e Assemblée.

Le remplaçant du Président du Conseil des Ministres de l'URSS **A. N. Kossyguine** monte sur la chaire. Il adresse des paroles de bienvenue aux participants et aux hôtes de l'Assemblée de la part du Gouvernement Soviétique.

—Le Gouvernement Soviétique—dit A. N. Kossyguine,— attache une grande importance à la collaboration internationale des savants.

N. A. Kossyguine a souhaité de la part du Gouvernement Soviétique aux participants de l'Assemblée du succès dans leur travail; il a exprimé l'espoir que leur activité réunie servira au développement des relations amicales entre les savants de tous les pays, et à la consolidation de la paix dans le monde entier.

Le discours du Professeur Danjon, Président de l' U.A.I. a marqué les grands progrès de l'astronomie. La X-e Assemblée se tient un an après l'expériment magnifique du lancement du premier satellite artificiel. Cette date sera inscrite en lettres d'or au nombre des grandes découvertes de l'histoire universelle.

L'académicien **A. V. Topitchiev,** vice-président de l'Académie des Sciences de l'URSS souligne dans son discours la nécessité du développement des liens scientifiques internationaux.

Les rapports et les relations des représentants de la science soviétique avec les savants étrangers se développent chaque année davantage.

L'académicien **V. A. Ambartsoumian** s'adresse ensuite à ses collègues soviétiques et étrangers. Il souligne que l'astronomie est redevable de ses succès à la collaboration des savants de différents pays.

L'académicien Ambartsoumian pense que les savants sont arrivés à une étape du développement de l'astrophysique qui permet de découvrir de nouvelles propriétés de la matière; ces propriétés ne pouvaient être révélées par des expériments de laboratoires terrestres.

L'inauguration solennelle s'est terminée par un grand Concert.

* * *

Le 13 août à 9h. du matin dans la Salle des Actes de l'Université de Moscou a eu lieu l'ouverture de la Séance plénière de la X-e Assemblée de l'UAI. Le Président de l'UAI, prof. A. Danjon a invité à honorer la mémoire de 28 membres de l'Union, décédés après la IX-e Assemblée, en se levant.

On a communiqué ensuite la lettre de compliment d'Ex-Président de l'UAI O. Struve.

Le secrétaire général de l'UAI le prof. P. Th Oosterhoff a fait son rapport.

La discussion unifiée sur l'observation astronomique des satellites artificiels de la Terre, des fusées et des ballons a eu lieu à 14 heures.

Des séances du Comité Financière et de la Commission unie de spectroscopie ont eu lieu simultanément.

The meeting place for the International Astronomical Union in 1958 was this new 32-story main building of Moscow University. It is located on high land in a southwestern suburb of Moscow, facing northeastward across the winding Moscow River toward the Kremlin, about four miles away. This is one of 37 buildings of the university.

World's Astronomers Meet in Moscow

BART J. BOK, *Mount Stromlo Observatory, Australian National University*

FROM August 12th to 20th, 1958, I was one of the thousand astronomers from all parts of the world who attended the 10th congress of the International Astronomical Union in Moscow. Now, while returning to Australia, I am writing this report on board the *Pobeda*, a beautiful white passenger vessel that crosses the Black Sea from Odessa to Istanbul.

FACING PICTURE: For the thousand astronomers who gathered in Moscow as guests of the Soviet Academy of Sciences, a special trilingual newspaper was published. This page, reproduced in facsimile, describes the opening ceremonies of the convention, which featured a symphony concert. Other social events during the eight days of the meetings included receptions at the Kremlin and at the embassies of the 35 nations represented. The newspaper featured articles on astronomical research by astronomers from many parts of the world.

The International Astronomical Union was still a small, compact organization when I attended my first meeting, at Leiden, Holland, in 1928. The commissions — there are about 40 — were effective working committees, each with a relatively small membership. We became alarmed when one commission, that on solar phenomena, grew to 40 members. Today, despite constant efforts to prune, some have memberships of between 70 and 80.

The Moscow congress will probably be remembered as the one at which the most effective pruning was done, though most of our commissions remain rather large. But I feel that the nominating committee, on which I represented Australia, made very few appointments of young astronomers to commissions. If the sound policy of keeping these groups small continues, rotating memberships should be instituted.

Congresses of the IAU feature, along with the commission meetings, a series of scientific symposia. At Moscow there were two major symposia, one dealing with the Hertzsprung-Russell diagram, the other with the earth's rotation and the associated problems of atomic time standards. Joint discussions, which were symposia in all but name, dealt with solar flares; artificial satellites, rockets, and balloons; luminosities of Cepheids; and the formation of chemical elements in the stars.

Attendance at these sessions varied from 300 to 1,000. Each person in the audience was provided with a portable radio and headphones, to allow the speaker to be heard in translation, if necessary. In spite of this effort, the symposia seemed the least satisfactory part of the congress. The professional translators performed marvelously, but the essence of the original presentation was lost. I preferred the brief summarizing translations by astronomers well versed in the subject matter, given just after each paper.

Furthermore, the large size of the audiences defeated the very purposes for which a symposium is held: discussion and a

Symposium sessions such as this were held in the second-floor auditorium of the main university building. Out of this picture in the right background were the three large soundproof booths for interpreters; through their radio headphones the audience could follow proceedings in English, French, or Russian.

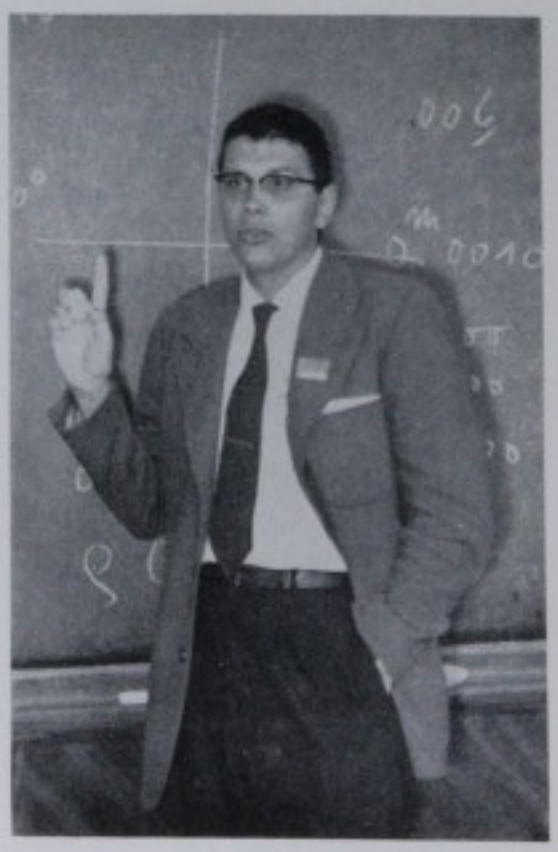
meeting of minds. At Dublin in 1955 we still had some good arguments from the floor, but these were lacking at Moscow. I think the IAU should in the future emphasize smaller symposia — along the lines of the Paris symposium on radio astronomy — held during the fortnight preceding the big congress.

For an astronomer like myself, primarily interested in Milky Way research and stellar evolution, there was much to learn. To illustrate the richness of the fare set before us, I select some items of particular interest in these fields.

New Galactic Pole. Milky Way astronomers will long remember the Moscow congress as the occasion when workers in this field decided by popular vote (with a little gentle prodding!) to adopt a different position for the galactic pole from that used over the past quarter of a century. (As the problem was described by Otto Struve in last month's *Sky and Telescope,* only the highlights need be mentioned here.)

In 1932 the IAU had officially adopted for the position of the north pole of the Milky Way right ascension $12^h\ 40^m$, declination $+28°$ (1900 co-ordinates). Soon after, the Swedish astronomer J. Ohlsson published very useful tables for the conversion of right ascension and declination into galactic co-ordinates. During the last decade, however, it has become increasingly apparent that the adopted galactic pole is in error by about a degree and a

Left: H. Beck of the Carl Zeiss works, Jena, East Germany, explains to R. d'E. Atkinson (left), Herstmonceux, England, the operation of a large double refractor that his firm is constructing for China. Almost completed is a Zeiss two-meter (79-inch) reflector for the new observatory near Jena of the German Academy of Sciences. It is convertible into a 53-inch Schmidt telescope.



Right: An American radio astronomer, W. C. Erickson of Convair Scientific Research Laboratory tells a commission meeting about the distribution of neutral hydrogen gas in our galaxy.

The Sternberg Astronomical Institute is the observatory of Moscow University (right far background). Its work includes radio time service, variable star researches, solar observations, and celestial mechanics.

half. The strongest evidence for this comes from the work of Dutch and Australian radio astronomers, as told in Dr. Struve's article.

The IAU subcommission charged with selecting a better pole was empowered, by vote of the general assembly, to decide on a final adopted position before the end of the year. Moreover, in the future galactic longitude will be counted from the direction to the galactic center, instead of from the intersection of the celestial and galactic equators, in Aquila. January 1, 1960, seems to be a desirable date for placing the new system in operation.

Cepheid Discussion. Our principal tool for plumbing the depths of space continues to be the Cepheid variable stars. Until a few years ago, the intrinsic brightness of a Cepheid variable was thought to be uniquely fixed by the period of its light variation. Now, however, it appears that each variety of Cepheid has a slightly different period-luminosity relationship. Doubt has also been expressed that the Cepheids in our Milky Way system, the Magellanic Clouds, and other galaxies are all of the same breed. The joint discussion organized by S. C. B. Gascoigne (Australia) and presided over by P. P. Parenago (U. S. S. R.) was intended to bring us closer to a solution of these problems. While many new and important facts were brought out, it can hardly be said that we have arrived at any firmer conclusions.

Mrs. C. Payne-Gaposchkin (U. S. A.) described the shapes and varieties of light curves for more than 600 Cepheids in the Magellanic Clouds observed over the past 35 years by H. Shapley and his associates at Harvard. Her paper and the following ones by Dr. Gascoigne and H. C. Arp (U. S. A.) showed that although many similarities exist between galactic and Magellanic Cloud Cepheids, there are important differences. One of the most striking of these is the overabundance (first recognized by Dr. Shapley) of rather short-period Cepheids in the Small Magellanic Cloud compared with the Large Cloud and our Milky Way system.

Similarity between galactic and Magellanic Cloud Cepheids was stressed by M. W. Feast and A. D. Thackeray (both of South Africa) on the basis of observations of spectra. On the other hand, G. E. Kron (U. S. A.) finds indications that the Milky Way Cepheids are intrinsically redder than those in the Small Cloud, but there was far from universal agreement on this point. More observations of high quality are needed.

The intrinsic luminosities of Cepheids were also discussed at length, but again the issues were not settled firmly. H. F. Weaver (U. S. A.) pointed out that many of the past discrepancies in determining the absolute magnitudes of Cepheids can be traced back to different assumptions as to the normal colors of these stars in our galaxy. For example, suppose we were to assume that the Cepheids are intrinsically quite blue, bluer than they actually are. Then the observed rather red color would suggest much space reddening, hence more obscuring interstellar dust between each variable and us than actually exists. We would be systematically underestimating the distance of such Cepheids from the sun, and an erroneous galactic distance scale would result.

The discussion at Moscow underlined the need for new observational data on the absolute magnitudes and colors of Cepheid variables. A recent breakthrough is the realization that numbers of Cephe-

Seen at a commission meeting, in the second row are, left to right, Geoffrey and Margaret Burbidge (U. S. A.), the writer of this article, and O. A. Melnikov (U. S. S. R.). Behind the last two sit J. H. Oort (Holland) and, right, J. L. Greenstein (U. S. A.).

The retired director of Leiden Observatory, Ejnar Hertzsprung (left), has contributed more to stellar astronomy than any other astronomer now living. Besides making the first H-R diagram and theoretical studies of fundamental importance, he greatly improved observational methods for variable and double stars.

ids are members of galactic star clusters. Since the distance of a cluster can be determined with high precision, we can obtain excellent estimates of the luminosity and intrinsic color of any Cepheid it contains. J. B. Irwin (U. S. A.) lists 11 Cepheids now known in galactic clusters, and work on their magnitudes and colors has begun.

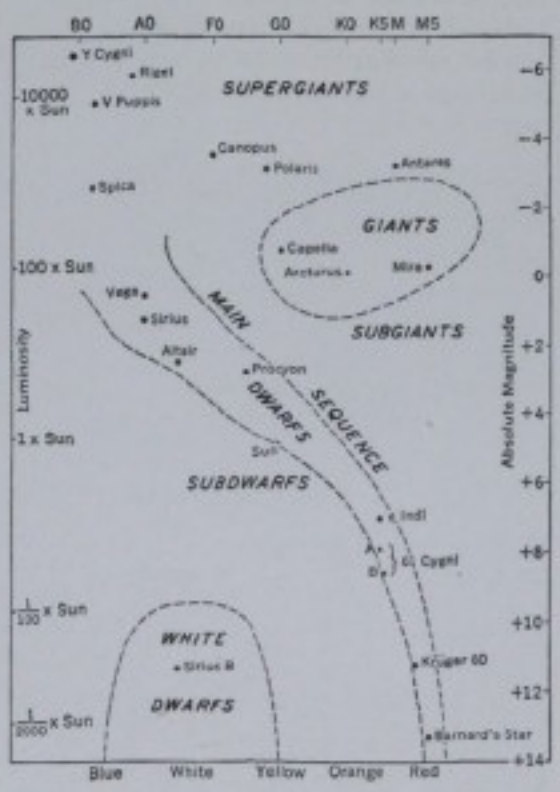
Two important contributions by Soviet astronomers included J. P. Pskovsky's review of the zero point of the period-luminosity relation, and E. D. Pavlovskaya's progress report on her measurements of the proper motions of cluster-type variables. The proper motions are derived by comparing star positions on recent photographs taken with the Sternberg Institute's 15-inch refractor with positions from old astrographic plates. There is general agreement that the cluster-type variables with periods a little under one day have absolute magnitudes averaging about +0.5 in blue light.

Magellanic Cloud Subcommission. There has long been a need for a group within the IAU to co-ordinate research on the Magellanic Clouds. Such a subcommission was established at Moscow under the direction of Dr. Gascoigne; it is part of Commission 28 (external galaxies). The group's tasks include preparing charts of the Clouds for observers, setting up standard sequences of star magnitudes and colors in the Clouds, and aiding the exchange of information among workers in this field.

Hertzsprung-Russell Diagram. Organized by J. L. Greenstein (U. S. A.) and E. Schatzman (France), the symposium on the H-R diagram covered a vast amount of material in its 20 papers. The first session, presided over by J. H. Oort (Holland), dealt with observations; the second, under V. A. Ambarzumian (U. S. S. R.), with theoretical problems. Unfortunately, H. N. Russell had died in February, 1957, but E. Hertzsprung (Denmark) was present in the full flower of his 83 years.

The H-R diagram is a plot of stellar spectral class (or color) versus absolute magnitude. During the half century this diagram has been used, its features, such as the main sequence, the giant branch, and the white dwarfs, have become part of everyday astronomical speech. More recently, we have come to look upon the H-R diagram as our chief way to exhibit the evolutionary tracks of stars of all kinds.

From precise studies of the spectra of stars, and from brightness measurements in different colors, much can be learned about the chemical composition of stellar atmospheres, which vary in a fairly well-determined manner with a star's age. G. and M. Burbidge (U. S. A.) gave a fine summary of the abundances of the elements in different types of stars. Those formed early in the history of our galactic system are found to be poorer in the elements heavier than hydrogen than are stars formed more recently. This aging effect is shown in extreme form by stars in globular clusters (presumably very ancient, five or more billion years old), as indicated by some of Dr. Greenstein's spectra.



This simplified H-R diagram shows the positions of many well-known stars in relation to the main sequence and other important named areas of the diagram. Adapted from "Astronomy," by Skilling and Richardson.

Hitherto relatively unpopulated areas of the H-R diagram are beginning to be filled in. In the lower left corner (domain of the hot, faint stars), Dr. Greenstein recognizes several subdivisions. The white dwarfs are there in the company of old novae, SS Cygni variables, blue-white stars in globular clusters and the galactic halo, and hot subdwarfs. The relations among these groups are not clear, but here truly is the celestial junkyard for worn-out stars.

During the initial stages of stellar evolution, stars develop by gravitational contraction. The T Tauri variables, young stars often found at the edges of dark nebulae, fill a wide band in the H-R diagram, between the giant branch and the main sequence, according to I. M. Kopylov (U. S. S. R.). These stars evolve along tracks of more-or-less constant absolute magnitude until they reach the main sequence, where nuclear transformations start in earnest.

With the development of theoretical interpretations of the H-R diagram, it is fortunate that new and more precise methods of placing particular stars in the diagram are becoming available. D. Chalonge (France) and his associates presented new results based on the French three-dimensional system of spectral classification, which permits a direct sorting of the stars by ages. Bengt Strömgren (U. S. A.) and coworkers are making excellent progress with multicolor observations, whereby even very faint stars are classified by photoelectric measurements at selected narrow intervals of wave length. Nancy Roman (U. S. A.) reported her success in finding subdwarf stars in the galactic halo by means of their excess brightness in ultraviolet light.

Briefly Noted. Some other scientific reports and happenings of particular interest to Milky Way researchers deserve mention. Perhaps most impressive are successes with image-converter tubes, the electronic devices that promise to revolutionize astronomical photography. Many of us saw for the first time the excellent results obtained in France with equipment built by A. Lallemand.

C. Fehrenbach and M. Duflot (France) told more about their measurements of

the radial velocities of stars, using an objective prism instead of the traditional slit spectrograph. Their second list contains radial velocities for 310 stars, with errors less than ±5 kilometers per second for the majority. Their equipment can reach stars as faint as 10th magnitude. This technique will be applied shortly to stars in the Magellanic Clouds.

The Czechoslovak astronomer J. Alter presented the commission on star clusters with a copy of his new general catalogue of clusters. In card form, it promises to have many uses in the years to come.

The commission on photometry made plans to issue during the next three years a general catalogue of magnitudes and colors of stars in both the northern and southern skies.

Astronomers continue to feel the need for a general catalogue of diffuse nebulae. A. W. Rodgers and his colleagues in Australia were urged by Commission 34 to proceed promptly with the preparation of an atlas and catalogue for the southern hemisphere, to be made from photographs taken with an 8-inch f/1 Meinel-Pearson Schmidt camera.

Several limited international symposia are being planned for the next few years. One on planetary nebulae and another on star clusters will almost certainly take place. There was discussion of a third, on galactic dynamics and the Magellanic Clouds. Other symposia planned are on site selection and on the aerodynamical problems of stellar atmospheres.

Some IAU Business. The big event at the concluding general assembly is always the selection of the new president and general secretary of the IAU. A. Danjon of Paris, who had been an excellent president, was succeeded by Dr. Oort of Leiden, a very popular choice.

P. T. Oosterhoff, also of Leiden, general secretary for the past six years, is being succeeded by D. H. Sadler of the British Nautical Almanac Office. New vice-presidents of the IAU are L. Goldberg (U. S. A.), R. M. Petrie (Canada), B. Sternberk (Czechoslovakia), and R. H. Stoy (South Africa).

Holland's J. H. Oort (center), president elect of the IAU, reaches for some abstracts of symposium papers at the Moscow meeting. A former president is at the left, Bertil Lindblad (Sweden), while between them is Nicholas U. Mayall of Lick Observatory. Waiting for them at the right are Mrs. Mayall and Carl K. Seyfert, Dyer Observatory.

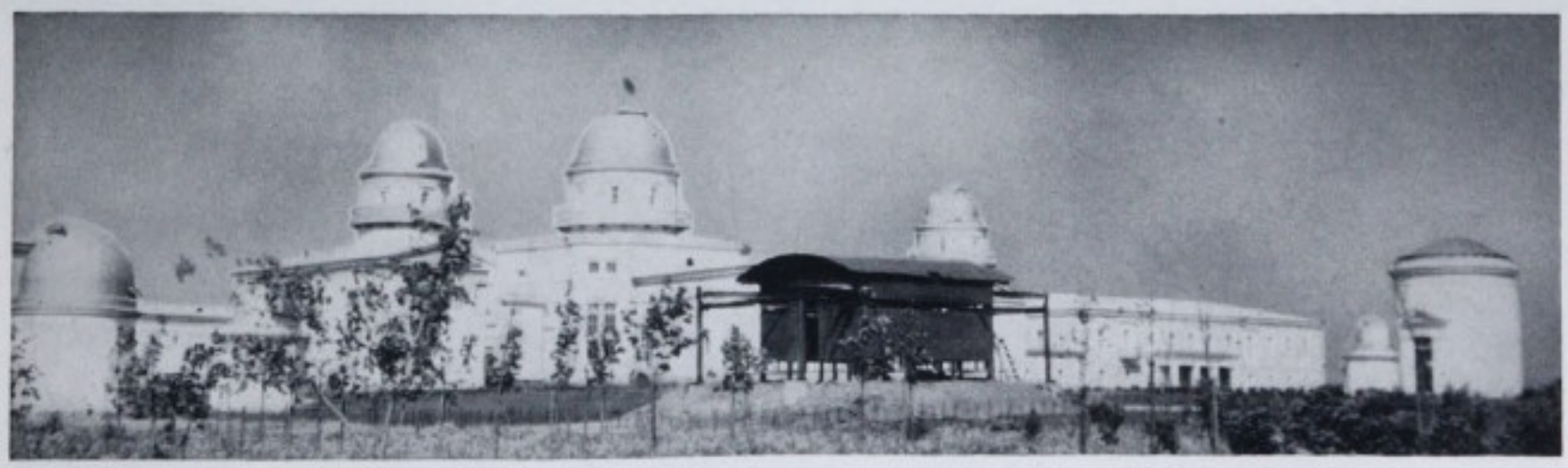
Among the new appointments of American astronomers to commission chairmanships are: F. P. Scott, positional astronomy; Dr. Goldberg, solar radiation; P. van de Kamp, proper motions and parallaxes of stars; N. U. Mayall, galaxies; L. Spitzer, Jr., diffuse nebulae; M. Schwarzschild, internal constitution of the stars; and others.

The four old commissions on solar problems were combined into two: No. 10, solar activity; and No. 12, solar radiation and the structure of the sun's atmosphere. Similarly, Commissions 29 and 36 were merged into a single Commission 29, for problems of stellar spectra. A new Commission 43 was established for magnetohydrodynamics and the physics of ionized gases.

The Moscow meetings were preceded and followed by excursions to the far-flung observatories of the U. S. S. R. I visited the Poulkovo Observatory in Leningrad before the congress began and the Crimean observatories afterward. Other astronomers went on trips to Georgia and Armenia, and quite a few left the Soviet Union via Leningrad, Odessa, or Tashkent.

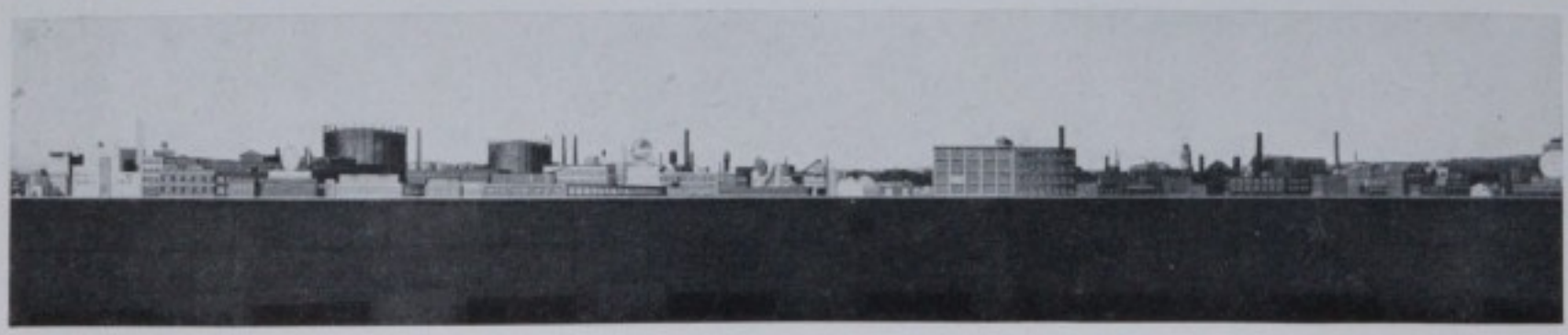
The U. S. S. R. seems destined to advance rapidly in astronomy. All of us return home deeply impressed by what the Soviet astronomers are doing to equip and staff their observatories. It is good, also, to have an opportunity here to acknowledge the fine hospitality of our Russian colleagues before, during, and after the Moscow meetings.

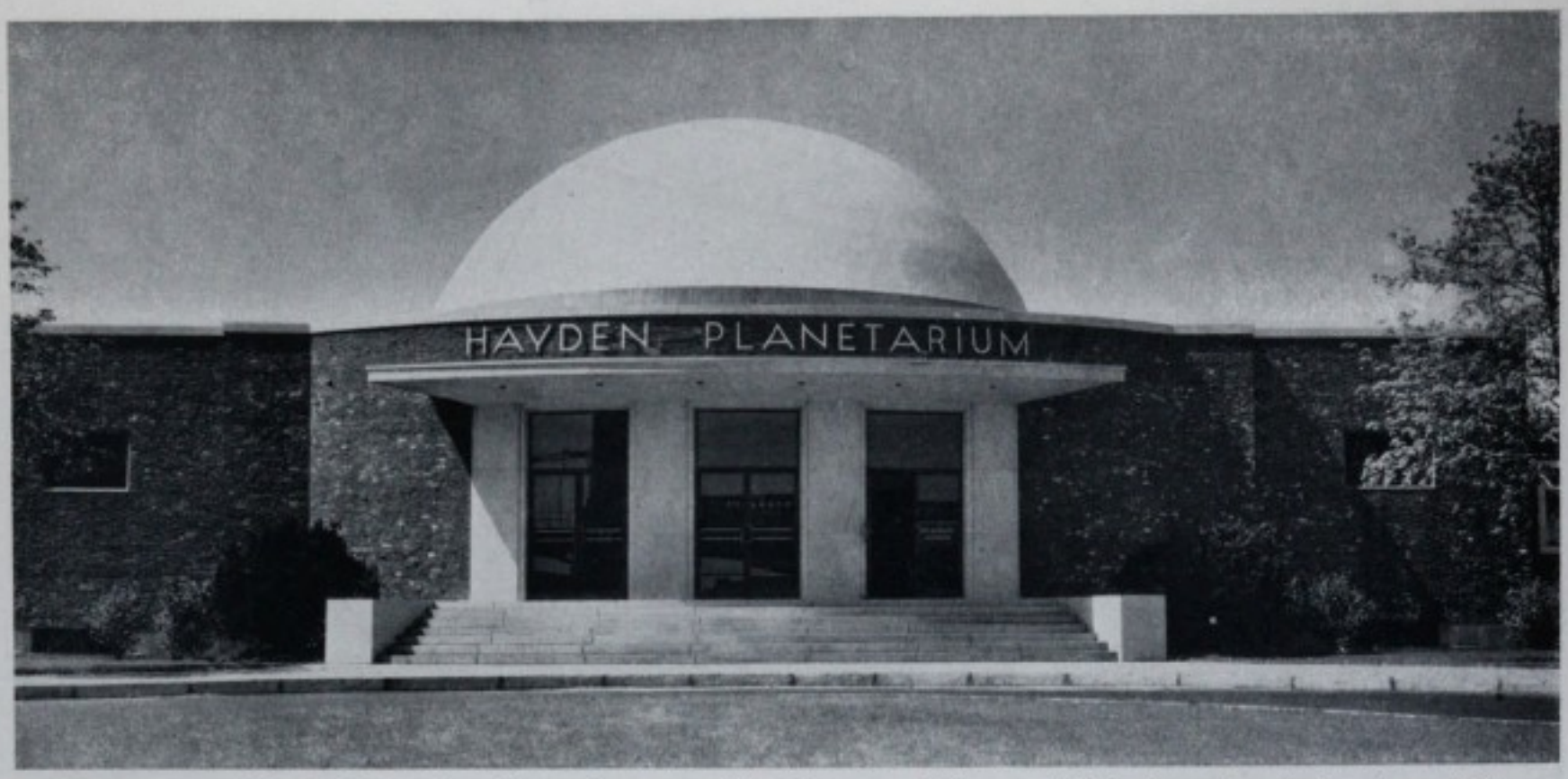
The 1961 assembly of the IAU will be held in the United States. Washington, D. C., Pasadena and Berkeley in California are among the possible meeting sites, but no decision among them has been made. The 1964 congress will probably be held in western Europe, with West Germany a likely place. Plans for 1967 and 1970 are still vague, but I had the honor of transmitting an Australian invitation for a meeting to be held at Sydney or Canberra.



The Poulkovo Observatory is situated on a hilltop 12 miles south of Leningrad, where these modern buildings were dedicated in May, 1954, as the famous institution had been destroyed during World War II. Several of the domes in this photograph by J. J. Nassau are part of separate observatory buildings.

Director John Patterson demonstrates the Charles Hayden Planetarium's new projector to a special audience. The parts of the Korkosz instrument may be compared with the key drawing on the facing page. The moving-planet projectors will be housed in the smooth ring spaces, between the quarter spheres (for faint stars) and the hemispheres (for bright stars). In the center of the instrument, the angle of 23½ degrees between the equator and ecliptic is plainly seen. The stars in this composite picture have been added by an artist. The photograph below, of a portion of the chamber's three-dimensional skyline, shows buildings on the Cambridge side of the Charles River basin.





The entrance to the Charles Hayden Planetarium, part of the Museum of Science, which is situated on land made available by the Metropolitan District Commission on the dam at the foot of the Charles River basin. The parts of the Korkosz projector are shown in the drawing below by Russell Lenz, of the "Christian Science Monitor." All photographs in this article are courtesy of the Museum of Science.

Boston's Planetarium Opens

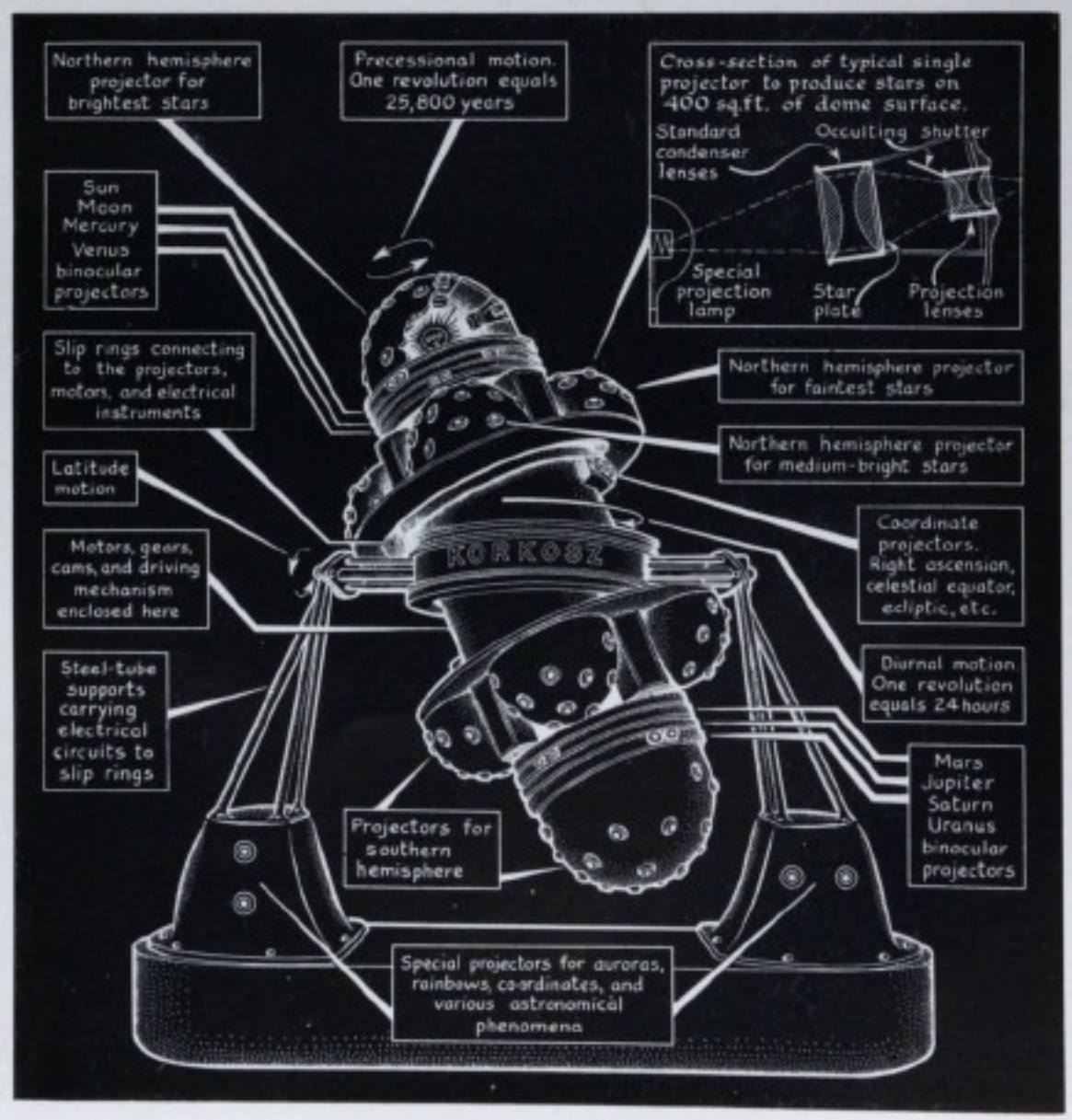
JOHN PATTERSON, *Charles Hayden Planetarium, Museum of Science*

MODERN planetariums are highly specialized theaters equipped with many ingenious instruments to create an illusion of the universe. Almost everything observable above the earth's surface is included, from meteorological phenomena of our atmosphere, through the motions of the planets and satellites of the solar system, to distant galaxies.

It is now more than seven years since *Sky and Telescope* readers first learned of our plans (May, 1951, issue, page 159) to build a major planetarium as part of Boston's Museum of Science, which is itself still in the process of development and construction. On March 13, 1951, the east wing of the museum was opened to the public; the planetarium was opened on October 21st of this year; the central building is being constructed as funds become available.

The opening of the planetarium climaxes many years of effort by Bradford Washburn, the museum's director, John and Frank Korkosz, inventors and builders of the projector, and a host of technicians, builders, and artists. We believe that in many respects the new Hayden Planetarium of Boston is the world's finest installation of its kind, even though we have opened it without the planet projectors. These are in final assembly at Springfield, Massachusetts.

As the sketch on page 15 shows, the building has every needed facility. The


Northern hemisphere projector for brightest stars
Precessional motion. One revolution equals 25,800 years
Cross-section of typical single projector to produce stars on 400 sq.ft. of dome surface.
Standard condenser lenses
Occulting shutter
Special projection lamp
Star plate
Projection lenses
Sun
Moon
Mercury
Venus
binocular projectors
Slip rings connecting to the projectors, motors, and electrical instruments
Northern hemisphere projector for faintest stars
Northern hemisphere projector for medium-bright stars
Latitude motion
KORKOSZ
Coordinate projectors. Right ascension, celestial equator, ecliptic, etc.
Motors, gears, cams, and driving mechanism enclosed here
Steel-tube supports carrying electrical circuits to slip rings
Diurnal motion One revolution equals 24 hours
Mars
Jupiter
Saturn
Uranus
binocular projectors
Projectors for southern hemisphere
Special projectors for auroras, rainbows, co-ordinates, and various astronomical phenomena

Above: Parts of the skyline depicting Massachusetts General Hospital are being installed by Gordon Mills.

Left: Frank Korkosz holds one of the Milky Way projectors. This unit employs a bright lamp and a two-mirror optical system to achieve the equivalent of pinpoint projection.

interior projection chamber is 60 feet in diameter and 38½ feet high. The seats are placed well within the periphery, so that no spectator is cut off from a view of the sky immediately behind him, and no one is seated under the lip of the chamber where he would lose the illusion of being under the starry vault of the heavens. Nevertheless, our seating capacity is 276, the maximum allowed us by the city's fire regulations. The seats have been specially designed to provide a restful observing position for each spectator.

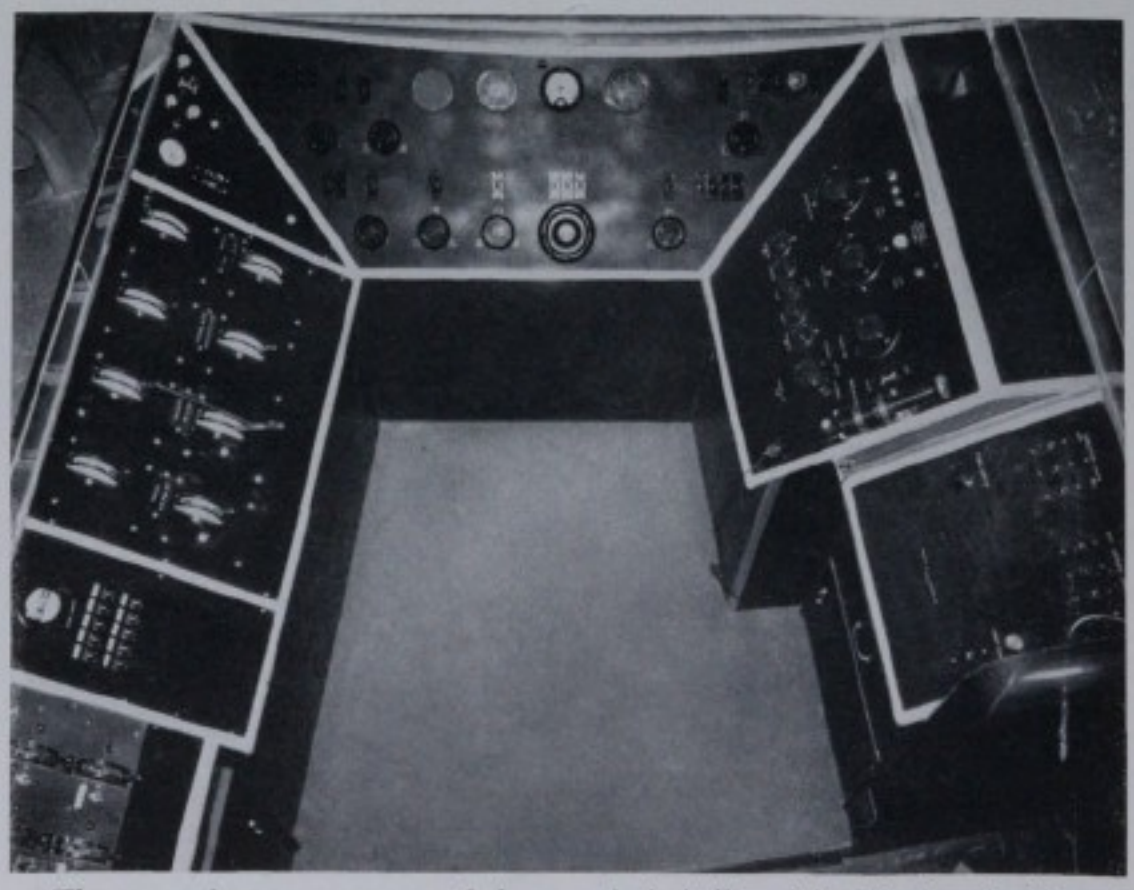
The dome is made of perforated aluminum having 15 holes per square inch, more than 12 million holes for the entire area. The dome horizon is 8½ feet above the floor, but it is not cut out or silhouetted in any way. At the press of a switch, the lecturer can employ a hydraulic system to raise into view a colored three-dimensional reproduction of the Boston-Cambridge skyline as seen from the museum, which is located at the foot of the Charles River basin. The panorama is complete with electric signs, John Hancock building weather signal, and electric clock. This skyline can remain in position during an entire lecture, or it may be lowered out of the way, to be replaced by other horizon effects produced by special projectors.

If the room is in darkness as the visitor enters the chamber, he can find a seat with the aid of a subdued red glow on the carpeted floor. The cardinal points of the compass are illuminated, as in other planetariums, and north and south can be reversed when a trip across the earth's poles is demonstrated. If a stop is made at the north pole, all the direction markers indicate south, since the observer is as far north as he can go.

Before the lecture begins, the audience sees the three-ton blue-and-silver projector in the center of the room — perhaps the only large planetarium projector that is not black! The instrument itself is protected by a metal rail, and within the enclosure are concealed some of the special-effects projectors. Together with those in the central portions of the instrument itself, they produce the ecliptic, celestial equator, meridian, north and south celestial poles, and mark out the precessional cycle. Also reproducible are a lunar eclipse, the rainbow, lightning, meteor showers, and the artificial satellites Sputnik I and Vanguard I.

In the new Hayden Planetarium, the demonstrator does not have to pass into the aisle of the audience chamber to get to the lecturing console. From his office he can go through a passageway to the technician's room, and then directly into the console. The latter incorporates all the controls, more than in any other planetarium, for the projector, special effects, lighting, and the sound system, the lecturer being independent of the technician for any of the effects that he may wish to use. About 8½ miles of connecting wires run from the desk to other parts of the chamber.

The left-hand panel of the console has



The convenient arrangement of the console is indicated in this view looking down from the skyline behind it. The dimmers at the left regulate the permanent and special lighting effects, planetarium projector controls are at the front, and sound and lights at the right.

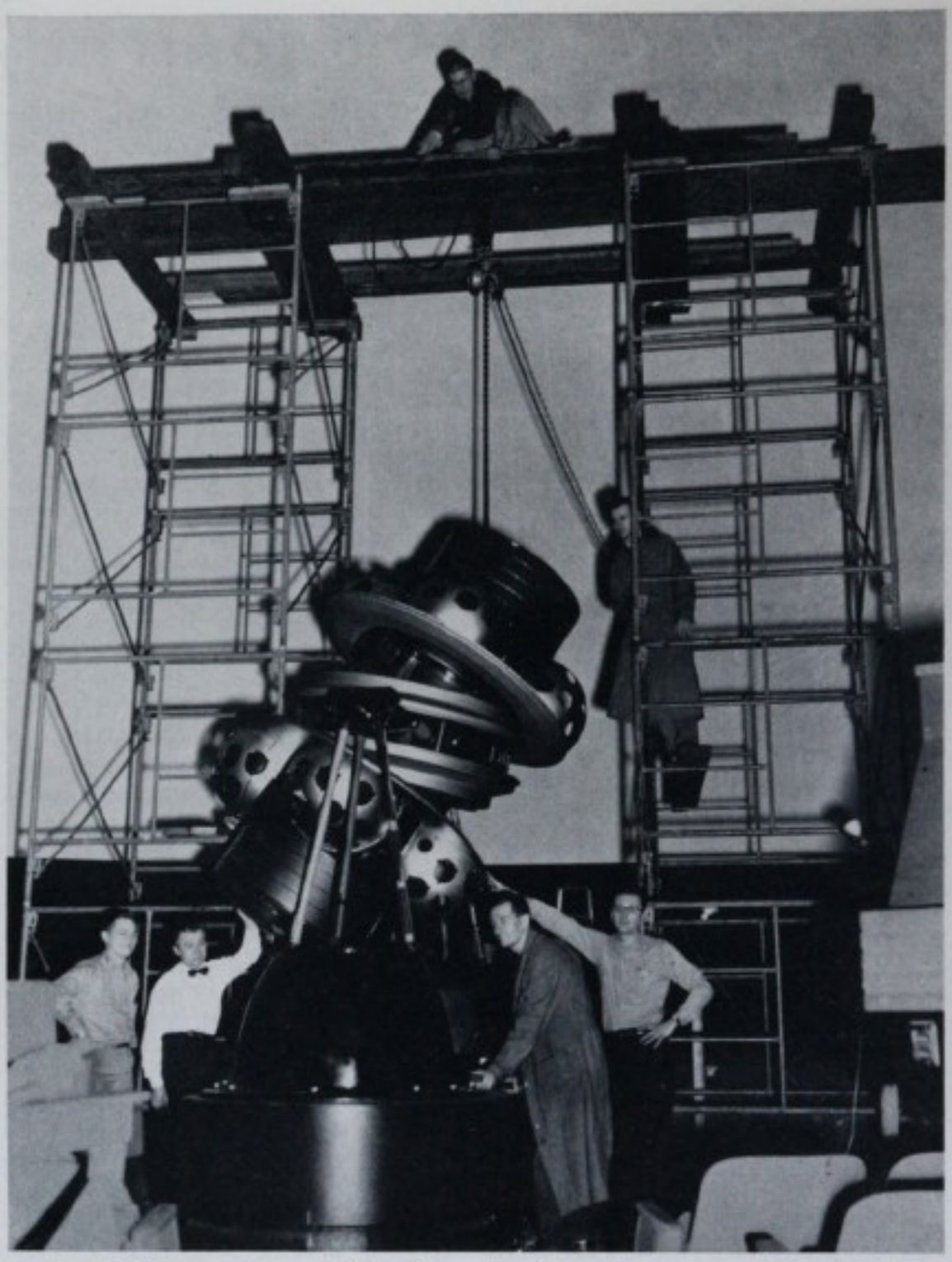
the special-effect switches and dimmers, the permanent lighting effects, and the hydraulic skyline controls. The front panel controls the projector itself, and has a latitude dial, time and date indicators that show the setting of the instrument, and an automatic clock. The latter operates a master switch turning off the entire electrical system, to prevent the instrument from running all night if someone forgets to turn it off. The right-hand panel controls the operational lights, cardinal points, entrance, and so forth, as well as the sound system.

Directional sound is provided by 32 speakers placed so that the apparent source can be made to go completely around the horizon or from one side of the chamber to the other through the zenith. Sound effects include passing trains, jet planes, jungle noises, thunder, and city traffic.

The labels of the control console are lighted dimly from behind – an aid to the lecturer. There are emergency battery-operated lights and a telephone within the lecturer's reach. One innovation is an elapsed-time counter which records the length of time the many lamps in the projection instrument are turned on and tells when to replace them.

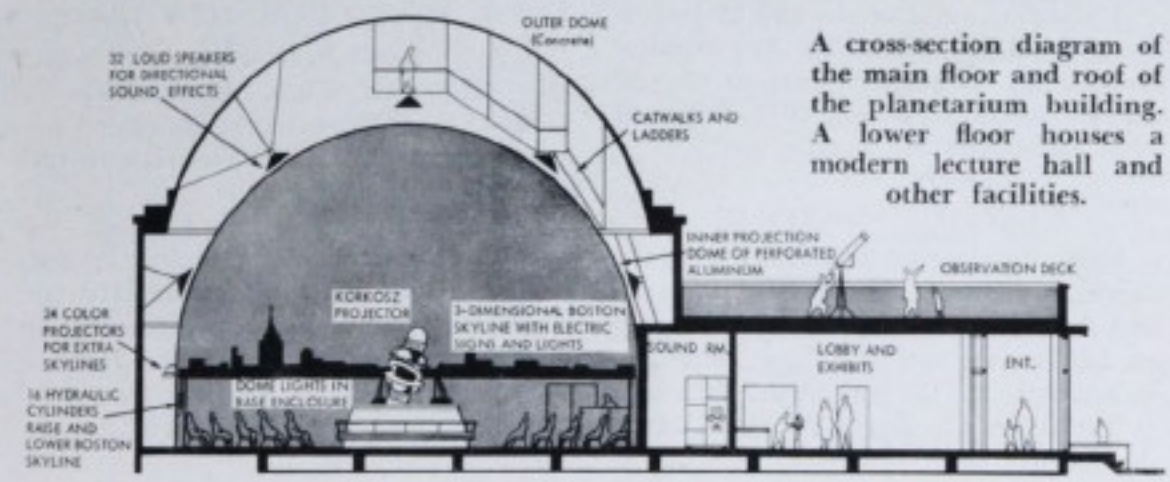
The Korkosz projector is unique, being the first of its kind. It produces a more realistic sky because light sources of different brilliance are used for bright, medium, and faint naked-eye stars. This has required a change in over-all design from the dumbbell shape of conventional projectors. In each of the hemispheres at the ends of the instrument is a 1,000-watt bulb, used for the 88 brightest stars in the sky, each one with its own optical system. In the quarter spheres there are 500-watt bulbs for 3rd- and 4th-magnitude stars, and 250-watt ones for 5th and 6th magnitudes, more than 9,600 stars being projected in all.

The Korkosz instrument incorporates all the refinements necessary in a modern planetarium projector. It provides for the motions of the planets, backward as well as forward in time, for change of the observer's latitude, for the 25,800-year cycle of precession, for the phases of the moon, and more. In designing it, standard motors and components have been used wherever possible.



A scaffold had to be erected in order to install the instrument. The author is at the top, and halfway up on the right is John Janek. Standing, left to right, are William and John Korkosz, Allen Thompson, and Stanley Korkosz. American Planetarium Corp. photograph.

Our initial schedule calls for 20 shows each week, with each lecture lasting about 50 minutes. The times on Tuesday, Wednesday, and Thursday are 9:45 a.m., 11:00 a.m., and 3:00 p.m. On Friday we add shows at 5:30 and at 8:00 p.m. The Saturday schedule is 11:00 a.m., 2:00 and 3:30 p.m., while on Sunday the times are 1:30, 2:45, and 4:00 in the afternoon. The 9:45 a.m. weekday lectures, for school groups only, will be by Valerie Roberts, who will integrate her talks into local school curricula. The lecturing staff consists of Walter N. Webb, Jackson F. Wilcox, and the writer. Our technicians are Charles S. Oates and Mr. Wilcox.


OUTER DOME (Concrete)
32 LOUD SPEAKERS FOR DIRECTIONAL SOUND EFFECTS
CATWALKS AND LADDERS
INNER PROJECTION DOME OF PERFORATED ALUMINUM
OBSERVATION DECK
KORKOSZ PROJECTOR
3-DIMENSIONAL BOSTON SKYLINE WITH ELECTRIC SIGNS AND LIGHTS
SOUND RM.
LOBBY AND EXHIBITS
INT.
24 COLOR PROJECTORS FOR EXTRA SKYLINES
16 HYDRAULIC CYLINDERS RAISE AND LOWER BOSTON SKYLINE
DOME LIGHTS IN BASE ENCLOSURE

A cross-section diagram of the main floor and roof of the planetarium building. A lower floor houses a modern lecture hall and other facilities.

Admission to the planetarium and museum together is one dollar for adults and 50 cents for children – half price for museum members.

New England's first major planetarium opens with great expectations of increasing interest and awareness of astronomy on the part of the general public. From the gigantic Chesley Bonestell mural of a panorama on the moon (August, 1957, *Sky and Telescope*), to the brilliant and nearly perfect rendition of nature's sky in the planetarium chamber, man's increasing knowledge of the universe will be presented for all to understand.

Amateur Astronomers

FT. WAYNE, INDIANA

With the support of the local press, radio and television stations, the Ft. Wayne Astronomical Society has made impressive progress since its formation last March (page 349, May issue). It now has 99 members, including 31 juniors. Meetings for the coming year will be held at the Elks Country Club on the third Wednesday of each month, and there will be one or more star parties.

There is an active telescope making group, with 42 telescopes now under construction. Two courses in basic astronomy are being planned – one being offered through the local branch of the Indiana University extension division, and the other being taught by Blanche Nielsen, a science teacher at Ft. Wayne Central high school.

Last July 11th, the society held a public exhibit in Shoaff Park, in co-operation with the park commission, attended by some 500 spectators. On display were a Minitrack station, telescopes, mirror grinding equipment, some astronomical movies, and rocket and satellite models. On July 23rd, about 350 persons viewed Jupiter and Saturn at a star party.

The society's officers are Herbert Krueger, president; Bert Leifer, vice-president; Harry McLain, treasurer; and Mrs. Margaret Wininger, R. R. 3, Hillegas Rd., Ft. Wayne, Ind., secretary.

FT. DODGE, IOWA

A group of 24 amateurs, half of whom are juniors, organized the Ft. Dodge Astronomy Club about eight months ago. Meetings are on the first and third Fridays of the month at 7:30 p.m. in the First Methodist Episcopal Church. The president is William W. Van Gundy, 1210 First Ave. N., Ft. Dodge, Iowa.

JUNIORS IN JAPAN

Created three years ago, the Japan Astronomy Club has 30 members throughout our country. The youngest member is 15 and the oldest is 22 years old. Since we cannot meet together, we communicate with each other by means of letters.

Each of us possesses a telescope, ranging from a 2-inch refractor to a 6-inch reflector. Our club publication is called the *Tentai*, which means "celestial body."

We would like to correspond with junior societies in the United States.

TAIZO MUTA
96-4 Kyomachi-3-chome, Kurume-shi
Fukuoka-ken, Japan

LAS VEGAS, NEVADA

A group of 21 adults and 13 juniors have formed the Astronomical Society of Southern Nevada. Further information may be had from the secretary, Tom Constanten, 1650 Michael Way, Las Vegas, Nev.

TROY AMATEURS REORGANIZE

After a year of inactivity, the Troy Astronomy Club was reorganized last August and now has 17 members. Monthly meetings are held on the first Saturday on the campus of Rensselaer Polytechnic Institute; an advanced group meets each Saturday at the R.P.I. Observatory.

We have the use of more than 13 telescopes, including the school's 12-inch reflector. Several members are now building a grinding machine that will hold mirrors up to 25 inches in diameter and can be adapted to 30 inches. We also publish a monthly bulletin of society news and astronomical data.

Interested amateurs in our area are invited to contact me.

DAVID HARRIS
1032 19th St.
Watervliet, N. Y.

BRISTOL, PENNSYLVANIA

Six amateurs have founded the Polaris Astronomical Society. The secretary is Alma K. Kovach, 3524 Carnarvon Ave., Bristol, Pa.

NEW YORK JUNIORS

The Junior Astronomy Club recently moved its headquarters from the Brooklyn Public Library to the Washington Square campus of New York University in Manhattan. The society has a membership of 400.

As part of its 30th anniversary celebration, the club is presenting a special lecture series, in addition to its regular monthly program, on "The Theory and Practice of Astronomical Observing." The speakers will be amateurs who have achieved prominence in such fields as meteors, variable stars, comets, and aurorae.

Newly elected officers are Joel S. Levine, president; Ian Fries, vice-president; Paulette Fote, secretary; and Leonard Richardson, treasurer. Arthur Pearlmutter is advisor. Inquiries about the group should be sent to Junior Astronomy Club, 100 Washington Square East, New York 3, N. Y.

KNOXVILLE, TENNESSEE

A group of eight adults and 23 juniors has formed the Knoxville Astronomical Association. Interested persons should contact David L. Bower, 2110 Fairmont Blvd., Knoxville 17, Tenn.

CLINTON, WISCONSIN

Active for the past year and a half, the Clinton Junior Astronomers has 11 members from 10 to 14 years of age. Meetings are held on the first and third Thursdays each month, at 7:30 p.m. in the clubroom at 244 Allen St. Roger A. Hamilton is the group's adult leader.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. November 6, Leon Campbell, Jr., Smithsonian Astrophysical Observatory, "The First Year of Moonwatch."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. November 14, Dr. Geoffrey Keller, National Science Foundation, "The New National Observatories."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health Museum Planetarium. November 24, R. T. Harvey, "Astronomy of Eratosthenes."

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., Pan American College science building. November 14, Paul R. Engle, Pan American College, "Lunar Missile Impact Survey."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. November 12, meteorologist from Truax Field weather station, "Weather, Radar, and the Stars."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. November 5, Dr. R. M. Emberson, Associated Universities, Inc., "The National Radio Astronomy Observatory."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. November 21, Dr. Martin Schwarzschild, Princeton University Observatory, "Astronomical Photography at High Altitudes."

Plainfield, N. J.: Amateur Astronomical Society of Bergen County, 6:30 p.m., Park Hotel. November 14, Charles A. Federer, Jr., Harvard Observatory, "Some Western Observatories."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. November 1, Leonard Batz, AC Spark Plug Division, "Gyroscopes and Earth Motion."

STAMFORD, CONNECTICUT

The Fairfield County Astronomical Society has formed a special division to meet the needs of younger people and others who wish to have proper preparation for the society's regular program. This group will meet on the second Monday of each month at 8 p.m. in the Stamford Museum.

UPPER MONTCLAIR, NEW JERSEY

Nine amateurs have set up the Montclair Telescope Club. Membership is limited to those actively interested in astronomy and who own, or plan to obtain or build, a telescope.

One member, Maxwell Kimball, an architect, has built a 5-inch refractor, and Richard Boegehold has constructed an 8-inch Newtonian. The club plans to set up a mirror grinding machine. Further information may be obtained from Mr. Boegehold, 280 N. Mountain Ave., Upper Montclair, N. J.

The Chemical Composition and Ages of Stars

OTTO STRUVE, *Leuschner Observatory, University of California*

ON MAY 27, 1958, Bengt Strömgren, now a member of the Princeton Institute for Advanced Studies and previously director of Yerkes and McDonald Observatories, delivered the Halley Lecture for 1958 at Oxford University. To an audience of British astronomers, he summarized investigations by himself and his colleagues in the field of photoelectric narrow-band photometry and its applications to problems of the composition of stars and their ages.

In the introduction to his discourse, Strömgren called attention to a fact emphasized in the 1933 Halley Lecture by H. N. Russell, who said: ". . . stellar spectra are remarkably similar *inter se*. The variety is much less than it would be if the relative abundances of many elements varied appreciably from star to star."

Hence, argued Strömgren, "the observed uniformity suggests that the problems of the interpretation of stellar spectra may be tackled successfully, in a first approximation, on the assumption of uniform chemical composition of the stars. As the analysis progresses, deviations from this simple picture, if they exist, will become apparent."

In recent years astronomers have found it convenient to describe the evolution of a star with a given mass in terms of an "evolutionary track" in the Hertzsprung-Russell diagram. One example of such a track is pictured here (Fig. 1). For stars of larger masses, the tracks lie higher in the diagram, and the shapes of the curves are not quite the same. But for stars in general we can distinguish four principal sections of the track.

First comes the stage of gravitational contraction, which carries the newly condensed star from right to left in the H-R diagram, and lasts only a relatively short time. Second, during the long-lasting main-sequence stage, the amount of energy generated by thermonuclear processes in the deep interior of the star is balanced by the energy radiated from the stellar surface into space. Third, as the hydrogen available for fuel becomes exhausted, the balance between energy produced and energy radiated is no longer maintained, and the star changes its characteristics fairly rapidly from those of the main sequence to those of the upper right corner of the diagram. Fourth, there is the final stage of very high central temperature, during which the star evolves more or less rapidly from right to left, crossing the main sequence, and ultimately becoming a white dwarf.

If two stars were to have different initial chemical compositions, say one was mainly hydrogen, the other mainly helium, the same four sections would occur, but their tracks would not coincide even for stars of the same mass. But, on Strömgren's assumption that stars have approximately the same initial composition, different evolutionary tracks represent differing stellar masses. In other words, the location of each track would depend solely on the mass of the star.

Then, if it were true that the tracks of stars of differing mass do not intersect, the precise location of the star on the H-R diagram would give us at once the mass of the star and its age. In general, we cannot make this assumption, for the tracks probably do intersect, even if the initial compositions are precisely the same, but with some simplifications, an assumption of nonintersection is likely to be valid.

First, suppose we can distinguish between stars in the early contracting stage

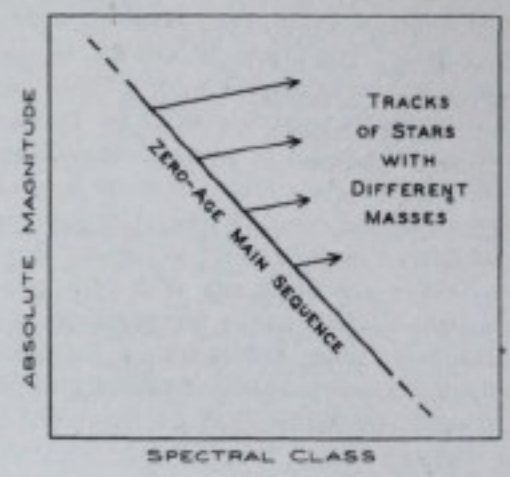


Fig. 2. The more massive a star, the higher in the H-R diagram is its track on leaving the main sequence, and the more rapid is its evolution.

and those in the much later hydrogen-exhaustion stage. Further, consider only stars, within a fairly narrow range of mass, that have not departed very greatly from the main sequence.

We will now consider the *B*-type stars, the hot, blue ones at the upper end of the main sequence. For these, the early contracting stage may be disregarded because it requires only a short time. We assign arbitrarily an age of zero to those *B* stars that are just beginning their main-sequence stage, and we follow the third evolutionary stages of stars of different masses, moving rightward from the main sequence, as in Fig. 2. These tracks do not intersect. Hence, to determine age and mass (if the latter is not already directly known from observation), all we need is to specify the exact location of the star in the H-R diagram. That is, we need only determine the star's absolute magnitude and spectral type, or their equivalents.

But conventional spectrographic methods have been of limited precision, and Strömgren has developed a more accurate way to classify spectra two-dimensionally. It is used to improve the classification after a good spectral type and absolute magnitude (or luminosity class) have been secured by the Morgan-Keenan or the Chalonge spectrographic procedures.

In the near-ultraviolet spectrum of early-type stars, there is a conspicuous drop in the brightness of the continuous

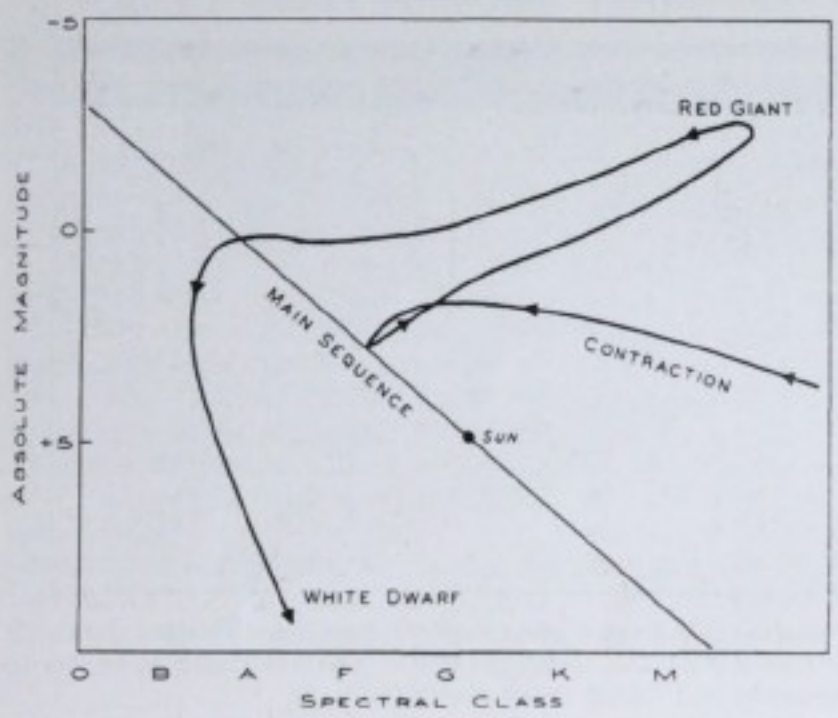


Fig. 1. Arrows trace the evolution of a star that contracts to reach the main sequence at spectral type F, where its thermonuclear processes begin in earnest. **(See page 584, September issue, for another recent representation.)**

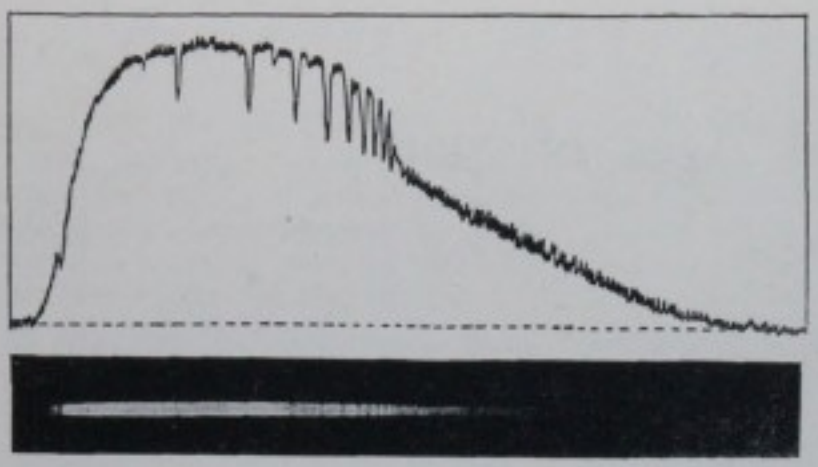


Fig. 3. This intensity tracing was made from the spectrogram that is shown below it, of a B3-type star. (Contrary to custom, the shorter wave lengths are toward the right.) The strongest lines are of hydrogen and helium; where they merge the continuous spectrum intensity falls off sharply—the Balmer discontinuity.

background as we pass from the long-wave-length to the short-wave-length side of the limit of the Balmer series of hydrogen lines. This drop is known as the *Balmer discontinuity* (Fig. 3). From the extensive spectrographic work by D. Barbier, by D. Chalonge and E. Vassy, and by Y. Ohman more than 20 years ago, we know that in *B*- and *A*-type stars (and to some extent also in *F* stars) the depth of the Balmer discontinuity is a very good indicator of the surface temperature.

Similarly, from the work of B. Lindblad, and more recently especially of R. M. Petrie, we know that the strength of the Balmer lines, for instance Hβ, depends mostly on stellar luminosity (Fig. 4), and only to a lesser degree upon the surface temperature. Hence, it should be possible to place any star in the H-R diagram for which the depth of the Balmer discontinuity and the strength of the Hβ line are known with high accuracy.

Strömgren's contribution is a method of measuring these two quantities with a photoelectric photometer. He makes six successive measurements, letting the star's light pass through each of six narrow-band filters:

Filter	*Peak Transmission* (angstroms)	*Band-width* (angstroms)
a	5000	90
b	4861 (Hβ)	35
c	4700	100
d	4500	80
e	4030	90
f	3600	350

The brightness of the star as observed through each filter can be called I_a, I_b, and so on, respectively. Then Strömgren computes two indices: l to describe the strength of the Hβ line, and c to describe the depth of the Balmer jump (Fig. 5):

$$l = 2.5\ (\tfrac{1}{2}\log I_a + \tfrac{1}{2}\log I_c - \log I_b),$$
$$c = 2.5\ (2\log I_e - \log I_d - \log I_f).$$

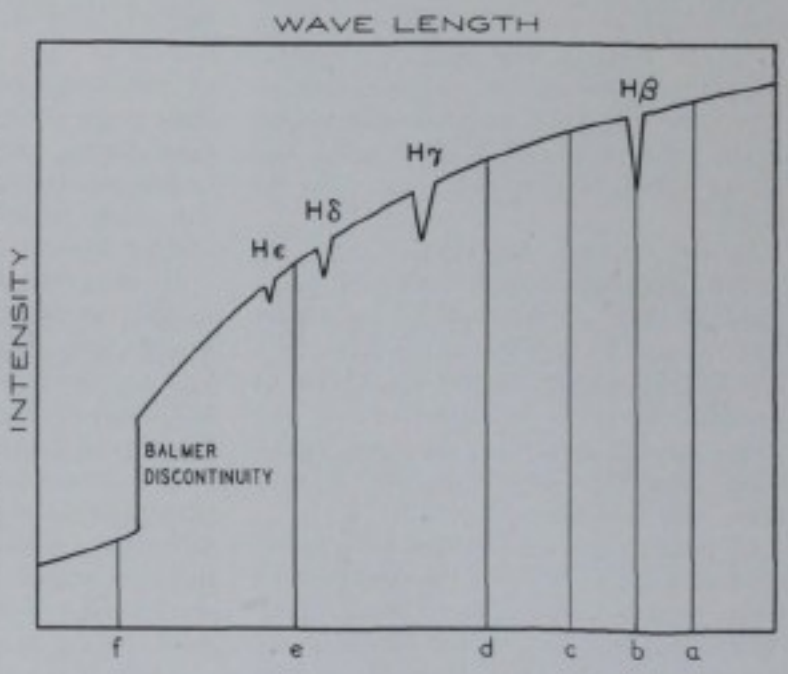


Fig. 5. In this schematic diagram of a stellar spectrum, a to f indicate the wave lengths at which B. Strömgren measures the brightness of the star. From them he deduces index numbers which describe the strength of the hydrogen-beta line and the depth of the Balmer discontinuity. These index numbers reveal the age and mass of the star.

The great advantage of these Strömgren index numbers is that they describe the star alone, being virtually unaffected by interstellar reddening. (The drawback to the conventional color index, photographic magnitude minus visual, is that it depends both on the intrinsic color of the star and the reddening effects of interstellar dust.) In the case of l, if the star is reddened, I_c will be depressed relative to I_a, but I_b will be depressed by an intermediate amount. The wave lengths of a and c were chosen nearly symmetrical with respect to b, to make the effects of space reddening cancel out in the formula for l. A similar argument holds for the other index, c.

Because of the extreme precision of photoelectric measurements, the probable error of one observation of l is only ± 0.004 magnitude, for $c \pm 0.008$ magnitude.

In order to study the ages and masses of the stars, it is not necessary to convert Strömgren's l and c indices into the conventional parameters, absolute magnitude and spectral class. He simply plots each star in a diagram such as Fig. 6, with l as the ordinate and c as the abscissa. To estimate the precision of his indices in terms of absolute magnitude and spectral class, Strömgren has calibrated l and c by means of W. W. Morgan's spectral types and a series of absolute magnitudes determined by A. Blaauw and by O. Eggen, D. K. Harris, and H. L. Johnson. The resulting probable error of one ob-

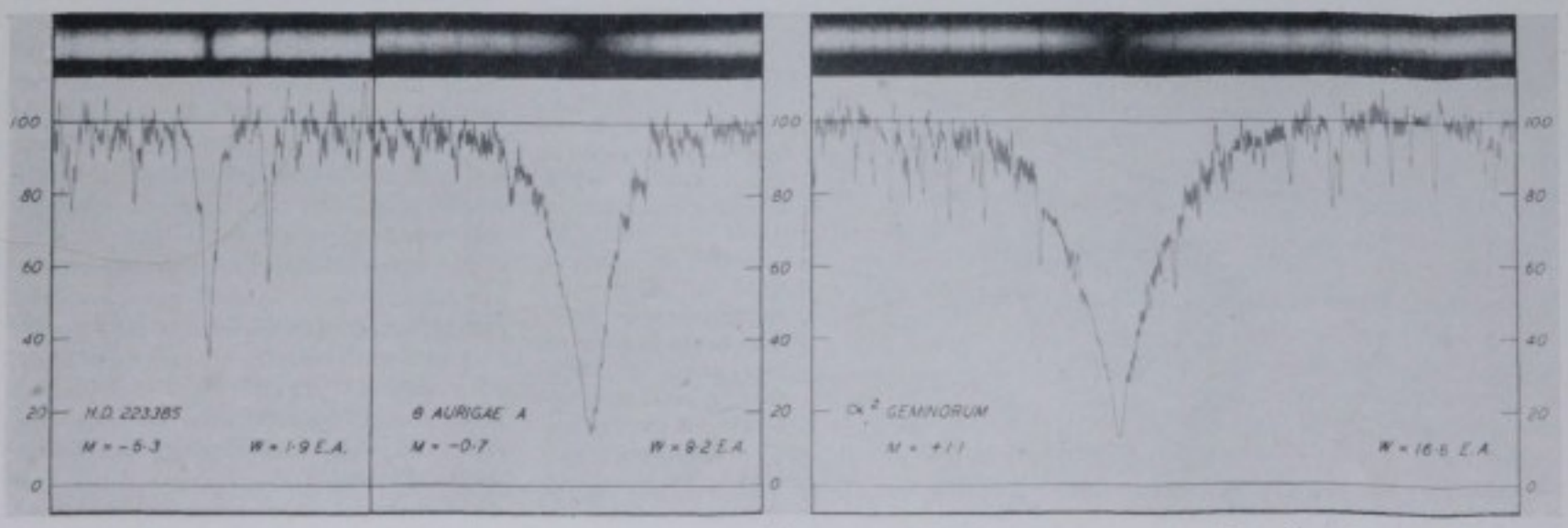


Fig. 4. The very strong dark line in each of these three stellar spectra is hydrogen gamma. Note how the width and depth of this line increase in passing, left to right, from the supergiant star HD 223385, to the giant star Theta Aurigae A, to the main-sequence object Castor. Dominion Astrophysical Observatory photograph.

servation by Strömgren is only 1/100 of a spectral class and ±0.02 to ±0.03 in absolute magnitude — very satisfactory precision indeed! The departure of a star from the main sequence in the *c-l* diagram is usually many times larger than these probable errors.

Let us examine Fig. 6, which contains stars of five luminosity classes, with supergiants (class I) at the top and marked by triangles. Some stars of the Pleiades cluster of early spectral type are included, marked by squares. The zero-age main sequence is represented by a line, derived independently from many measurements of the *l* and *c* indices of very young stars belonging to two stellar associations in Orion and Scorpius (I Orionis and II Scorpii). These stars are not plotted in the diagram.

We see that the supergiants of type *B* are easily distinguished from other *B*-type stars. Strömgren does not discuss their evolution. The other stars lie above the zero-age main sequence by different amounts, indicating differing evolutionary ages.

In Fig. 6, Strömgren has superimposed upon the star plot a network of curves computed from the theoretical work of R. J. Tayler and R. S. Kushwaha. The roughly horizontal bars are evolutionary tracks, while the longer, thin lines approximately parallel to the zero-age main sequence represent different ages. These curves apply to stars of spectral type *B3* and later.

Strömgren has discussed, as one example, the brighter members of the Pleiades that fall in this part of the *c-l* diagram. From Fig. 6 we see that their ages lie between 50 and 75 million years (with one near 100 million), in good general agreement with other estimates of the age of this cluster: W. Lohmann's 100 million years and S. von Hoerner's 80 million.

Early in this article we discussed Strömgren's beginning assumption — that all *B* stars had the same initial chemical composition. To test this hypothesis, he compared his own measurements of *l* and *c* with the best available spectral types and absolute magnitudes for stars in the associations I Orionis and II Scorpii. If the initial compositions of these two associations had been unlike, stars with the same *l* and *c* would have different absolute magnitudes or spectral types in the two groups. However, it turns out that the compositions are the same, to within about 10 per cent in the ratio of hydrogen to helium, and about the same in the ratio of hydrogen to heavy elements.

We cannot be certain that this uniformity of initial composition applies to *all* stars. Strömgren points out that the two associations he compared both belong to the same spiral arm of the Milky Way galaxy. It would be interesting to extend the comparison to associations in other spiral arms, and to the Magellanic Clouds.

Finally, Strömgren asks the question: Are there other physical processes in stars that might appreciably distort their evolutionary tracks? If there are, then two stars having identical values of *l* and *c* would not necessarily have equal masses and ages. He mentions differences in rotational velocities and magnetic properties of the stars, and differences resulting from the presence of hydrogen emission lines. The available evidence is not sufficient to ascertain whether these effects are appreciable. To these possibilities we might add mass exchange and mass expulsion in close binary systems like Beta Lyrae and U Cephei. There is in fact other evidence that the evolutionary tracks of members of such binary systems may differ drastically from those of normal single stars.

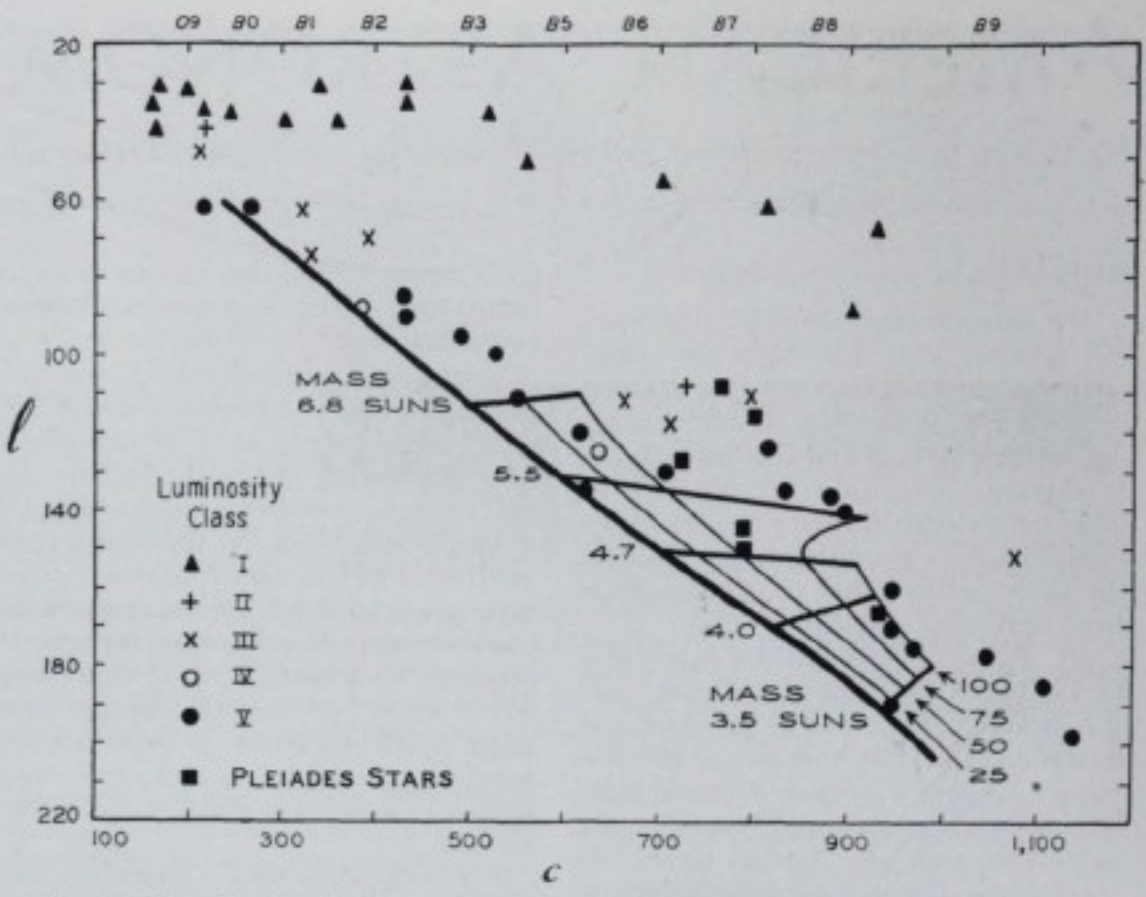


Fig. 6. Plotted points in this c-l diagram by Strömgren represent B- and A-type stars he has observed. The long, thin lines nearly parallel to the main sequence, which are labeled 25, 50, 75, and 100, are ages in millions of years since the stars left the main sequence. The luminosity class I refers to supergiants, III to giants, and V to dwarfs.

TO CANOSSA

Nearly 900 years ago, Emperor Henry IV of the Holy Roman Empire crawled on his knees into the presence of Pope Gregory VII at Canossa to do penance and induce the pope to lift the excommunication that had been pronounced against him. Today I "go to Canossa" to do penance before the readers of *Sky and Telescope* for having made a serious slip in my September article on the orbits of visual double stars.

The error was pointed out by Charles Mariano of the Polytechnic Institute of Brooklyn. The plastic-sheet method I described works only if an additional piece of information is already known, for example, the orientation of the line of nodes by the Stewart-Henroteau process. (The diagram at the top of page 551 is to be replaced by the one on page 617 of the October issue.) The line of nodes then serves as a sort of hinge around which the plastic is turned until the desired coincidence of lines occurs. Without this additional information, there are, as Mr. Mariano states, "an infinite number of orientations of the plastic such that the perpendicular lines drawn on it project upon the lines AB and CD in the apparent ellipse."

OTTO STRUVE
Leuschner Observatory

NEW DIRECTOR AT LOWELL

John S. Hall became director of Lowell Observatory, Flagstaff, Arizona, on September 1st. He is the fifth astronomer to head the famous institution founded by Percival Lowell to observe Mars during its 1894 opposition. The other directors have been V. M. Slipher, A. G. Wilson, and E. C. Slipher.

Dr. Hall is a photoelectric specialist, well known for pioneer work in infrared photometry, the polarization of starlight, and atmospheric scintillation. Such fields of observation are of growing importance in the solar-system problems that have always been the main work of Lowell Observatory.

For the last 10 years, Dr. Hall has been at the U. S. Naval Observatory, where he is being succeeded as chief of the astrometry and astrophysics division by K. A. Strand (see page 22).

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 100th meeting of the American Astronomical Society at Madison, Wisconsin, in June, 1958. Complete abstracts will appear in the Astronomical Journal.

High-Altitude Meteoritic Dust

The most efficient means yet developed for collecting dust that enters the atmosphere from outside the earth was reported by P. W. Hodge and J. S. Rinehart, working at the Harvard and Smithsonian Astrophysical observatories. A collecting device of the design sketched here has been carried aloft in airplanes, to levels where the air is relatively free of contamination from terrestrial sources.

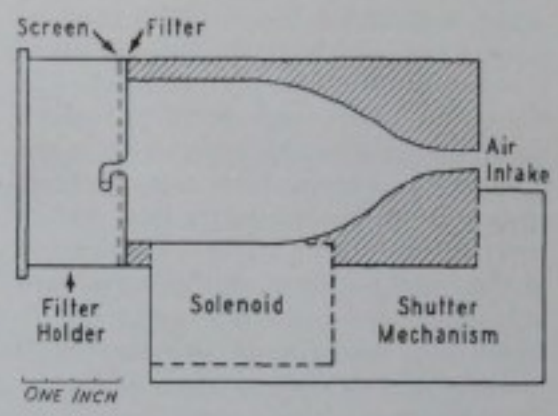
Jet aircraft of Edwards Air Force Base in California have made 22 flights into the stratosphere carrying Rinehart collectors. At the plane's maximum altitude, the pilot opens a solenoid-operated shutter, uncovering the six-millimeter intake hole of the collector. The air passes into a collecting chamber two centimeters in diameter, where it deposits any solid particles on a millipore filter supported by a wire screen.

When the plane returns to earth, the filter housing is removed, and fresh filters can be quickly installed without contamination. The collection times have ranged from five minutes to about 3½ hours. At heights above 50,000 feet, the total accumulation during one hour is about 1,000 particles of over 0.002-centimeter diameter.

Microscopic examination of the collected material has revealed several distinct varieties of particles. In addition to those originating within the collector itself, there were semitransparent blobs of terrestrial dust. But the remaining eight per cent of the particles appeared to be of extraterrestrial origin. Some were shiny black chunks, others cindery frameworks of metallic appearance up to 0.02 centimeter across. A small percentage were shiny black spherules, a type already generally recognized as meteoritic from studies of collections made at the earth's surface.

It is planned to have a dozen Rinehart collectors in operation in a few months. Together they will provide large enough samples for detailed chemical analysis.

In another paper presented to the society, C. L. Hemenway and E. F. Fullam, Dudley Observatory, told of their examination of these extraterrestrial particles by electron-microscope and electron-diffraction techniques. The larger of the particles, which they believe to be micrometeorites, show evidence of cratering. This pitting appears to be due to impacts by meteoritic particles of submicron size. Their study shows that these smaller bodies occur in large numbers.



The Rinehart collector is a compact device carried aloft by aircraft to collect micrometeorites, which are deposited on the filter from the stream of air entering the intake.

Electron-diffraction examination of the micrometeorites revealed no evidence of crystalline structure. At least some of these bodies were found to be magnetic.

The nebula IC 405, photographed in blue light by G. H. Herbig of Lick Observatory, with the 36-inch Crossley reflector. The interloping star AE Aurigae makes these dust clouds visible by reflection. North is above, east to the left.

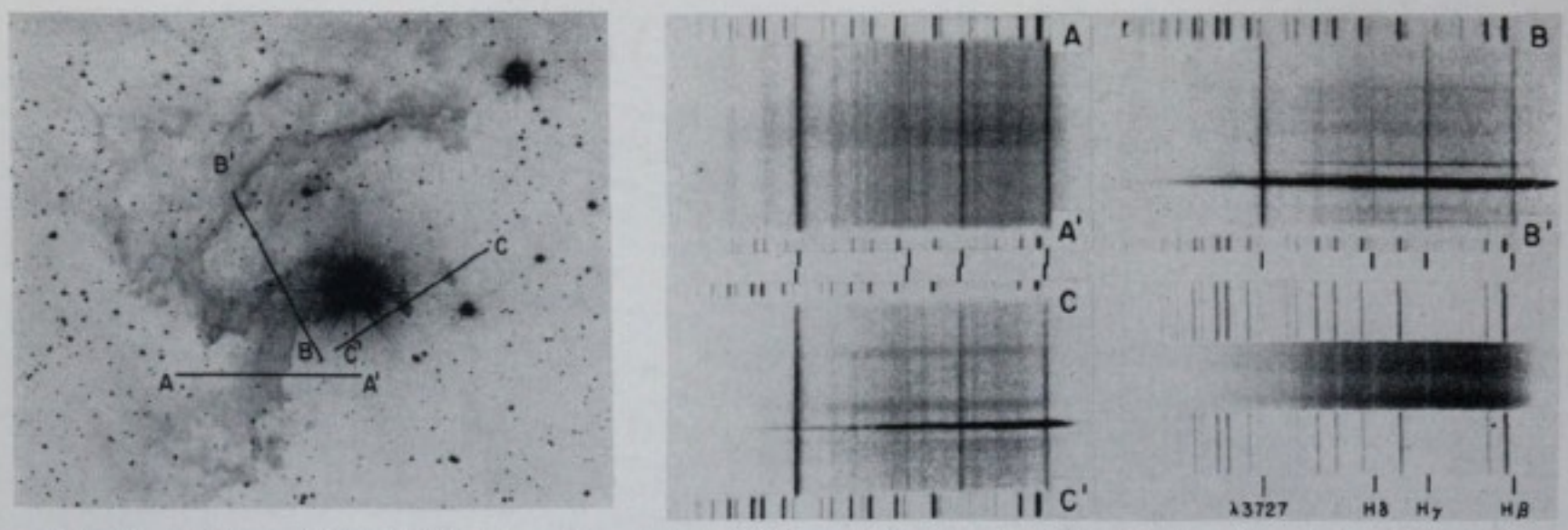
An Unusual Reflection Nebula and the Star AE Aurigae

When a hot star of early spectral type lies inside or very near a gaseous nebula, the strong radiation of the star at very short wave lengths ionizes the atoms in the nebula, which then becomes self-luminous by recombinations of the electrons and ions in the gas. The nebulosity has a spectrum characterized by bright emission lines of hydrogen, oxygen, and other elements.

If dust is involved in the nebulosity, the spectrum may also have a reflection component that mirrors the spectrum of the star itself, while at great distances from the star, where its radiation is too weak to cause the ionization processes, the nebula's spectrum may be entirely of the reflection type.

There is, however, the case of IC 405, which appears to be illuminated by the 6th-magnitude star AE Aurigae, of spectral type *O*9.5. George H. Herbig, Lick Observatory, believes the peculiarities of IC 405 indicate that the star and this nebula have been close together for a relatively short time.

AE Aurigae is one of the early-type objects that is receding with a high velocity from the I Orionis star association (*Sky and Telescope*, March, 1954, page 156). It is moving through the sky at a rate of 128 kilometers per second at a distance from us of about 500 parsecs. Its motion



The direct photograph (left) of IC 405 was taken in blue light by Dr. Herbig, who labeled the locations of the spectrograph slit for the first three spectra at the right. The lower-right spectrum is of the star AE Aurigae. He used the Crossley nebular spectrograph, with a dispersion of 430 angstroms per millimeter and a slit scaling six minutes of arc long. The strips of continuous spectrum are due to the reflection nebula, while lines not extending the full slit length are from the emission nebula. All photographs on these two pages are from Lick Observatory, University of California.

in the line of sight (radial velocity) is about 59 kilometers per second away from us. On the other hand, IC 405 is receding at only about 22 kilometers per second. Thus, AE Aurigae seems to be a recent interloper in the nebulosity.

IC 405 has two distinct components, a complex emission nebulosity and some streamers that appear to be dust. This is illustrated by these two photographs made by Dr. Herbig with the Lick 36-inch Crossley reflector. Both have the same scale and show the same part of the sky.

Almost all of the bright nebulosity shown in the blue photograph (3800 to 5000 angstroms) has a continuous spectrum, except for some filaments north of the star. Compare this appearance to that in the red photograph (6300 to 6750 angstroms), where all of the nebulosity shown has a predominantly emission spectrum.

Representative spectrograms of three sections of IC 405 are reproduced above, together with the spectrum of AE Aurigae (lower right). The respective positions of the slit are indicated on the small picture of the nebula. The dark strips of continuous spectrum are due to parts of the "blue" nebulosity, while the bright lines of hydrogen and ionized oxygen (3727 angstroms) arise in the emission component. Other emission lines are due to the night sky and city lights.

Does the continuous nebulosity consist of dust illuminated by starlight? The most straightforward test fails: Bright hydrogen lines of the emission nebulosity are present to some extent on all the spectrograms, and so mask the possible presence, in the continuous nebulosity, of Balmer absorption lines from ordinary scattering of AE Aurigae's light by dust.

The presence of dust is indicated, however, by an inspection of direct photographs, which show that the distribution of stars in the vicinity of AE Aurigae is not at all uniform. Thus, dust may be causing some absorption of starlight, and this possibility is confirmed by the fact that in all cases the brighter parts of the continuous nebulosity coincide with lanes where there are apparent deficiencies of faint stars. This observation is based on star counts in a photograph taken by Dr. Herbig in the wave-length region 5250-5850 angstroms, where both nebulosities are very faint.

The material responsible for the blue nebulosity probably has very little free gas associated with it, otherwise this would show on the red photograph. This conclusion runs counter to the belief that gas and dust are always associated. Hydrogen 21-cm. line observations would be of considerable interest, to detect the presence of regions of unionized gas in IC 405.

It is noteworthy that none of the dust structure lies directly south of the star. It may not have existed there originally or, since that is the direction from which the star has come, there may have been enough time for the dust particles in that

Compare the facing picture with this red-light exposure of IC 405, in which the dust clouds are not seen, but a wholly different nebular structure of luminous gas is brought out. The star AE Aurigae is the brightest one of this photograph, and is below the center.

direction to have been modified by the star's radiation.

The Lick astronomer postulates the following picture of the association of AE Aurigae and IC 405. The star, in its northward motion, has encountered two nebulae: a large low-density gas cloud which the radiation of the star has ionized, and some dust streamers which only scatter the star's light. As the star is moving very rapidly, the dust has not yet had time to change its properties in the new radiation field. Given sufficient time, the nebula will presumably be greatly modified.

QUESTIONS... FROM THE S+T MAILBAG

Q. In what constellation is Barnard's "runaway" star?

A. It is in Ophiuchus, at right ascension $17^h\ 55^m.7$, declination $+4°\ 35'$ (1959.0 co-ordinates), about 0°.6 west and 0°.2 north of 5th-magnitude 66 Ophiuchi. Barnard's star has the largest proper motion known, carrying it one minute of arc northward every six years. Of visual magnitude 9.5, this red dwarf has a spectrum of type *M*5, and is only seven light-years distant.

Q. Why can't we see the other side of the moon from the earth?

A. The moon has a permanent tidal bulge toward the earth, so that as it revolves around us it keeps the same side toward us. Thus, its periods of revolution and rotation are locked together, and a lunar day is a month long.

Q. How much of the moon's surface has actually been seen?

A. Small periodic variations in aspect, known as librations, permit us to look around the edges and over the top and bottom of the hemisphere of the moon that faces us, so that 59 per cent of its surface has been observed.

Q. What is the annual displacement of the equinox due to precession?

A. This displacement is 50.27 seconds of arc per year along the ecliptic. Its component in right ascension is 3.07 seconds of time, in declination 20.04 seconds of arc.

Q. Why will a 2-inch telescope show 9th- or 10th-magnitude stars, while a 15-inch will only show slightly more than four magnitudes fainter?

A. Four magnitudes represent a brightness ratio of about 40; a 15-inch telescope gathers about 50 times as much light as a 2-inch.

Q. Which asteroid was named after an ocean steamer?

A. No reader has yet answered this query by Owen Gingerich on page 517 of September, 1957. Perhaps the allusion is to 724 Hapag, which spells the German initials of the Hamburg-America Line.

W. E. S.

NEWS NOTES

COMET BURNHAM-SLAUGHTER

The fifth comet discovered in 1958 was found at Lowell Observatory, Flagstaff, Arizona, on September 7th by R. Burnham, Jr., and by C. Slaughter. It was a diffuse 14th-magnitude object in the constellation Equuleus, moving slowly westward.

Preliminary calculations of the orbit of Comet 1958e have been made by Dr. Elizabeth Roemer, at the U. S. Naval Observatory's Flagstaff station, from observations on September 7th, 15th, and 21st. They indicate that the new object will be closest to the sun in March, 1959, the minimum distance being 1.65 astronomical units. However, so far the apparent motion of the comet has differed little from a great circle on the celestial sphere, and this makes any orbit computations uncertain.

The predicted right ascension and declination are $20^h\ 21^m.2$, $+14°\ 56'$ (1958.0) for November 3rd; and $20^h\ 29^m.7$, $+18°\ 21'$ on December 3rd. The object should be brightening.

This is Mr. Burnham's third comet. He discovered 1958a on February 21st, and less than four months earlier was a co-discoverer of Comet 1957f.

SOUTHERN OBSERVER OF VARIABLE STARS

Since most observatories, professional and private, are located in northern latitudes, the important work of maintaining visual observations of variable stars in the far southern sky is carried out by relatively few persons. According to the July *Monthly Notes* of the Astronomical Society of Southern Africa, R. P. de Kock of Capetown has now passed the 100,000 mark in his estimates of variable star magnitudes. He began this work in 1933, and his annual total has averaged about 6,000 since 1950. Most of Mr. de Kock's observing is carried out with the 6-inch refractor of the Royal Cape Observatory.

ANTIREFLECTION COATINGS FOR INFRARED OPTICS

Infrared spectroscopy has become a valuable tool of astronomy, but at very long wave lengths celestial bodies other than the sun are weak sources, making improved observing techniques highly desirable. Today rather large pieces of infrared-transparent germanium and silicon can be made for use as infrared windows and image-forming elements. At Ft. Belvoir, Virginia, J. T. Cox and G. Hass have been developing thin antireflection coatings for these materials.

They have succeeded in preparing very durable coatings which provide a transmission of 98 per cent or better at any desired wave length in the infrared up to about 15 microns. Evaporated films of silicon monoxide appear best for the near infrared. For the region of eight to 14 microns, where silicon monoxide is not sufficiently transparent, zinc sulfide is very suitable. Hitherto, coatings of zinc sulfide had not proved durable, but it has now been found that careful glow-discharge cleaning just before deposition on material heated to at least 150° centigrade cures this difficulty.

Details of this work are given in the October, 1958, *Journal* of the Optical Society of America.

STARS OF CLASS R

The relatively rare red stars of type *R* have spectra characterized by bands of carbon and cyanogen. An extensive survey of their properties has been completed at Leander McCormick Observatory by G. L. Vandervort. With a photoelectric photometer he has measured the magnitudes and colors of 98 of these objects, finding that the color index increases from +1.2 for *R*0 stars to +2.1 for *R*8 ones. Of the 98 stars, 21 are variable in brightness.

From the proper motions of these stars (determined in 41 cases by Dr. Vandervort himself) and their published radial velocities, he could find their average luminosity. The visual absolute magnitude is about +0.4 for *R*0 and *R*2 stars, and −1.1 for those with *R*5 and *R*8 spectra.

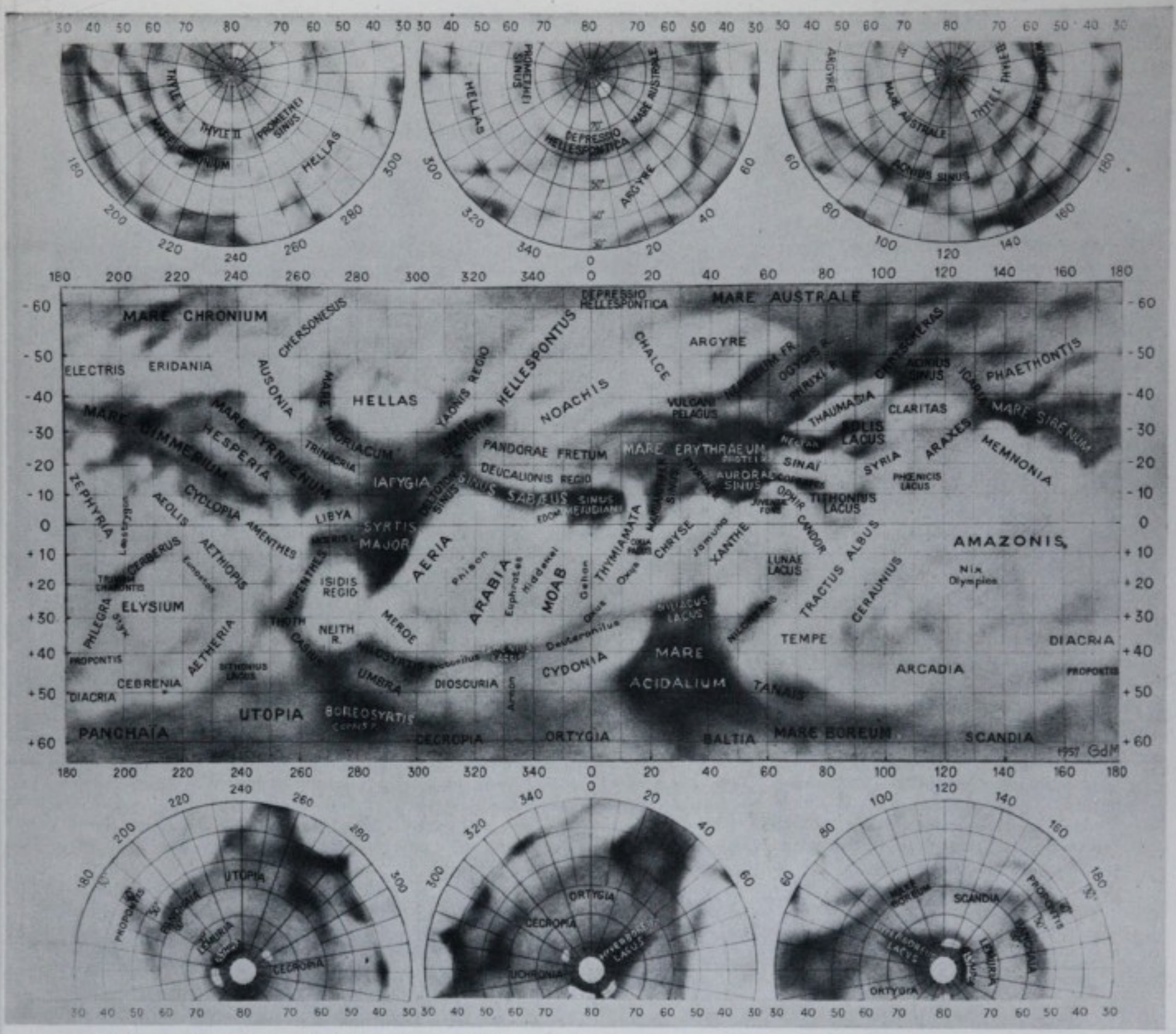
Dr. Vandervort's investigation continues the long series of studies at McCormick Observatory concerning the systematic motions of stars having different spectral types. His classifications were made on A. N. Vyssotsky's fine collection of objective-prism spectrograms, taken with a 10-inch refractor, which cover the entire sky visible from the observatory at Charlottesville, Virginia.

WASHINGTON APPOINTMENT

K. A. Strand has been named to direct the astrometry and astrophysics division of the U. S. Naval Observatory, Washington, D. C. The Danish-born astronomer had been director of Dearborn Observatory, Northwestern University, where he specialized in precise photographic measurements of double stars. Dr. Strand will continue his connection with the University of Chicago as a research associate with the rank of professor in the astronomy department.

IN THE CURRENT JOURNALS

THE TAILS OF COMETS, by Ludwig F. Biermann and Rhea Lüst, *Scientific American*, October, 1958. "It has long been assumed that the gases of a comet tail are pushed away from the comet by the pressure of light from the sun. It now appears that many tails are caused by a wind of charged particles."



The International Astronomical Union's map of Mars, showing the 128 proper names officially adopted for large, fairly permanent regions. Drawn by G. de Mottoni, these charts and the one on page 25 were based on photographs taken at Pic du Midi Observatory during six oppositions of Mars from 1941 to 1952. (Some lettering on this photograph has been retouched for reproduction purposes, and a few misspelled names corrected.)

The New IAU Nomenclature for Mars

JOSEPH ASHBROOK, *Harvard College Observatory*

OBSERVERS of the planet Mars have long been burdened by the unwieldy system of names for its dark and bright surface markings. In an effort to assist Martian studies, the International Astronomical Union adopted a simplified and more convenient system at its Moscow assembly in August.

The traditional names for the surface features are an outgrowth of G. V. Schiaparelli's mapping of Mars in 1877 with the 8-inch refractor of the Milan observatory. As the Italian astronomer made his sketches at the telescope, he assigned to each new feature that he drew some geographical name, usually in Latin or Greek form. Thus arose such familiar Martian designations as Hellas (Greece) and Ausonia (Italy). Newly discovered "canals" he named after rivers, for example Indus, Ganges, and Nilus. The terrestrial counterparts of most of these names can be identified with the aid of an atlas of classical geography.

As Schiaparelli continued to observe Mars at opposition after opposition, later with an 18-inch refractor, his list of names grew. Hundreds of other designations in the same spirit were added by Percival Lowell and by E. M. Antoniadi. The latter's 1930 book, *La Planète Mars,* contains a map based on all previous observations, with over 550 named formations. Still more recent additions have been made, for example those by the Association of Lunar and Planetary Observers.

This unsystematic nomenclature has now begun to break down under its own weight. There are far too many arbitrary names to be conveniently remembered. Different designations are sometimes used for the same formation by different au-

Fact Sheet on the Planet Mars

Characteristics of the Planet	
North celestial pole of Mars (1950 co-ordinates)	R.A. 21h 07m.2 Dec. +53°.0
Inclination of Martian equator to its orbital plane	24°.8
Length of Martian day	24h 37m 22s.7
Equatorial diameter	4,200 miles
Length of one degree of latitude on Mars' surface	37 miles

*Characteristics of the Orbit**	
Mean distance from the sun	1.5237 A.U.
Eccentricity of the orbit	0.0934
Longitude of perihelion	335° 17′
Inclination of the orbit	1° 51′
Longitude of ascending node	49° 14′
Martian year	686d 23h 30m 41s

Seasons in the Northern Hemisphere of Mars begin when the planet is at the following heliocentric longitudes: spring, 84°.0; summer, 174°.0; autumn, 264°.0; winter, 354°.0.

*Orbital elements are values for 1958.

thors, and in other cases the exact identity of the marking to which a particular name applies remains uncertain. Also, since all surface features of Mars are more or less subject to change, numerous names apply to temporary minor details that disappeared many years ago.

Hitherto, any one designation system has not served equally the needs of observers using instruments of widely differing resolving power. When very large telescopes are used to observe Mars under favorable seeing conditions, the named dark areas are resolved into complex fine structures.

The International Astronomical Union in 1952 set up a special Subcommission 16a to reform the Martian nomenclature. Its chairman was the veteran French planetographer G. Fournier. After his death in 1954, the project was continued by A. Dollfus of Meudon Observatory. The other members of the subcommission were H. Camichel (France), G. P. Kuiper and G. Van Biesbroeck (U. S. A.), G. de Mottoni (Italy), A. F. O'D. Alexander and M. B. B. Heath (England), and N. P. Barabashev (U. S. S. R.). Many other planetary observers offered their recommendations. At the 1958 IAU congress, the reformed system of Martian names proposed by this group was formally adopted.

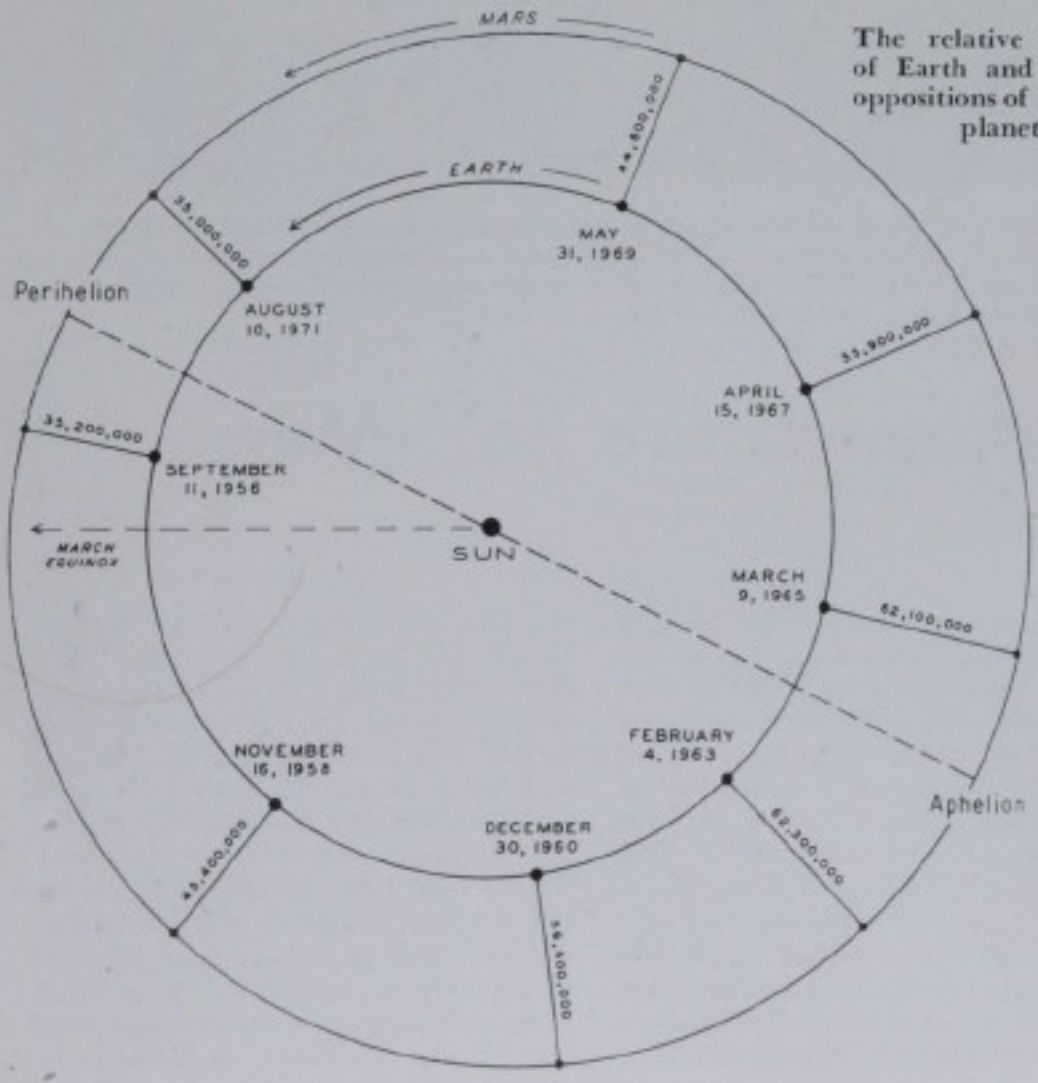
The aims of the new system are:

1. To keep the nomenclature simple even if future observations of Mars reveal much more detail.

2. To be convenient for photometric, spectroscopic, or polarimetric observers who can isolate only fairly extended areas of the planet's surface. Such studies are often undertaken by scientists not familiar with the traditional Martian names.

3. To avoid drastic changes from earlier usage by making the system understandable by anyone acquainted with the previous designations.

To achieve these aims, **large regions** will retain the proper names already in use. These are the quasi-permanent features that preserve their identities over many years, despite seasonal and other changes. Each such proper name is an over-all designation for a region as a whole.



The relative positions of Earth and Mars at oppositions of the latter planet.

The number of official proper names is thus reduced to 128, distributed almost uniformly over the surface of Mars. These areas were selected from the list of 404 reported to the IAU by Fournier, which in turn was a pruning of Antoniadi's 558 in his 1930 list.

The IAU subcommission has introduced a few changes and additions to existing names:

1. Thaumasia Felix is now simply *Thaumasia*.

2. The hitherto unnamed bright region centered on longitude 75°, latitude −20°, has been named *Sinai*, because of its nearness to Mare Erythraeum (the Red Sea).

3. Another nameless region, at longitude 100°, latitude −20°, near Phoenicis Lacus, has been called *Syria*.

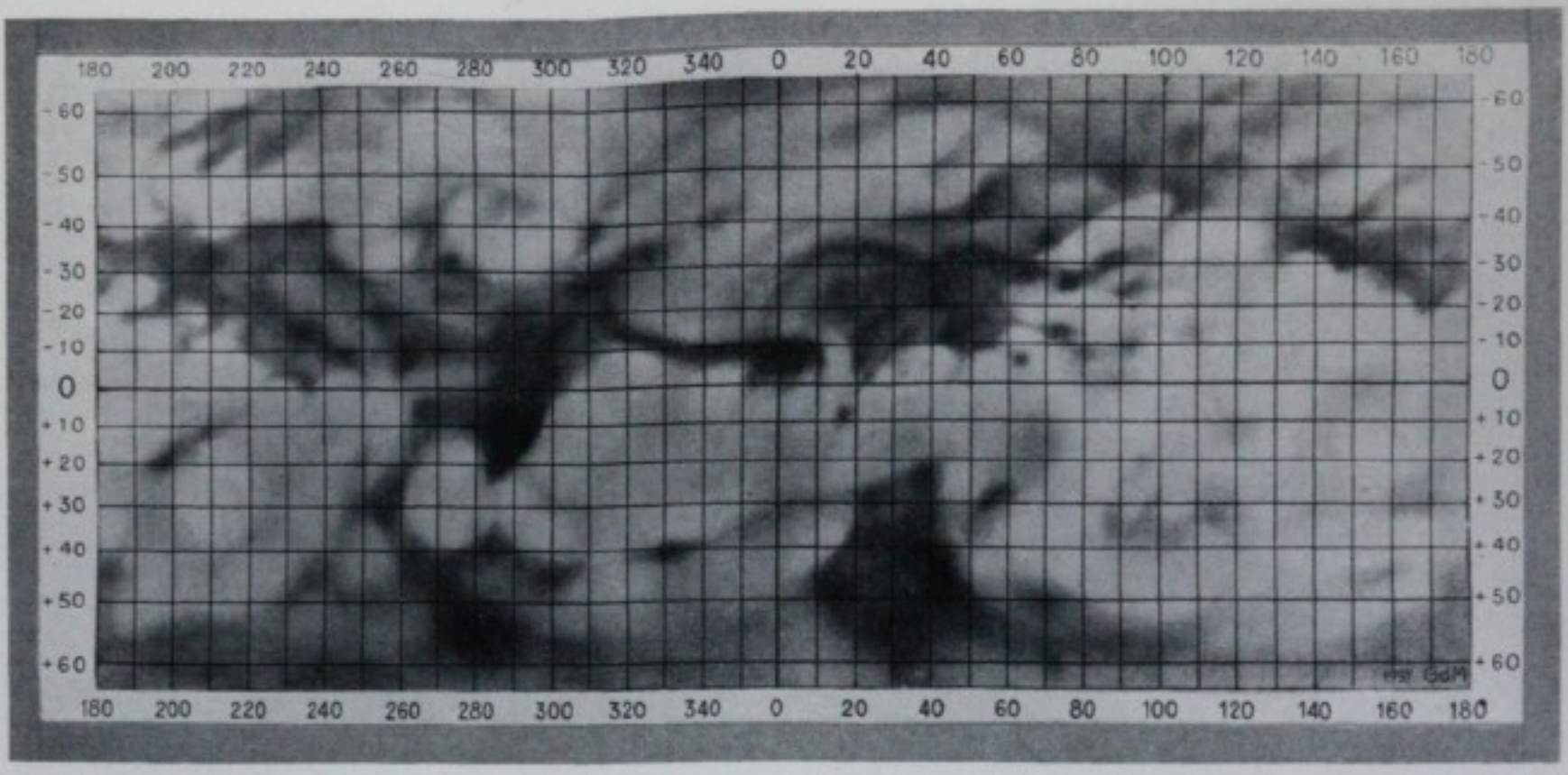
4. Of the two areas known previously as Ausonia Australis and Ausonia Borealis, the former is now to be called *Ausonia*, the latter *Trinacria* (Sicily).

The main novelty of the new system is that **small details** are henceforth to be known not by names but by their approximate Martian longitudes and latitudes. For example, 189°, +20° will designate a marking whose longitude is 189° and latitude +20°. These labels have the advantage over the older names of indicating location on the planet's surface.

To facilitate the use of the new Martian nomenclature, the IAU subcommission has compiled a catalogue of the 128 adopted names, and a chart identifying them. For the smaller details, maps with only the necessary co-ordinate grid were supplied. These charts are reproduced in *Sky and Telescope* at the request of the IAU, to make them available to observers during the present close approach of Mars to the earth. The next volume of the IAU *Transactions*, which will contain the full report on Martian nomenclature, will not be published for one or two years.

The maps were drawn by de Mottoni from the many exquisite photographs of Mars secured at Pic du Midi Observatory during the oppositions of 1941, 1943, 1946, 1948, 1950, and 1952. He first made six charts, one for each year, and from these compiled a final map, showing surface markings that appeared reasonably permanent over the interval 1941-52.

Special care was taken by Dollfus and his coworkers in providing an accurate co-ordinate grid for the maps. All the better measurements of Martian longitudes and latitudes were collected and



The de Mottoni map of Mars printed without names, to facilitate reading grid co-ordinates of minor details.

compared. The orientation of the grid is defined by Camichel's recent and precise determination of the location of the north pole of Mars. He found that the rotational axis of the planet, when prolonged, intersects the celestial sphere at right ascension $21^h\ 07^m.2$, declination $+53°.0$ (1950 co-ordinates). His result, which supplants all previous work, is from measurements of Pic du Midi photographs from 1941 to 1954. This study also gave 9".33 as the diameter of Mars when viewed from a distance of one astronomical unit; this corresponds to 4,200 miles.

While the new Martian nomenclature was adopted unanimously by the astronomers meeting at Moscow, some criticisms have been expressed by several other experienced observers of the red planet. The map is perhaps the most reliable available, but it shows only about the amount of detail visible to an experienced observer in a 6-inch telescope. The needs of workers with considerably larger instruments may not be adequately met.

There are a number of discrepancies between map names and those in general use that could cause confusion. For example, the designation Thoth has been transferred to the marking Nodus Laocoontis, while the useful name Coloe Palus has been dropped, this marking now becoming part of Nilosyrtis. Perhaps the IAU will take action to correct such discordances.

Serious observers of Mars would welcome publication of a collated list of names, giving for each marking the synonyms used by Schiaparelli, Antoniadi, Lowell, and others. In any event, it would be well for Mars observers to indicate in their reports of observations whether or not they are using the IAU map and nomenclature as a basis for identifications.

The 128 Named Martian Features

Acidalium Mare (30°, +45°)
Aeolis (215°, −5°)
Aeria (310°, +10°)
Aetheria (230°, +40°)
Aethiopis (230°, +10°)
Amazonis (140°, 0°)
Amenthes (250°, +5°)
Aonius Sinus (105°, −45°)
Arabia (330°, +20°)
Araxes (115°, −25°)
Arcadia (100°, +45°)
Argyre (25°, −45°)
Arnon (335°, +48°)
Aurorae Sinus (50°, −15°)
Ausonia (250°, −40°)
Australe Mare (40°, −60°)
Baltia (50°, +60°)
Boreosyrtis (290°, +55°)
Boreum Mare (90°, +50°)
Candor (75°, +3°)
Casius (260°, +40°)
Cebrenia (210°, +50°)
Cecropia (320°, +60°)
Ceraunius (95°, +20°)
Cerberus (205°, +15°)
Chalce (0°, −50°)
Chersonesus (260°, −50°)
Chronium Mare (210°, −58°)
Chryse (30°, +10°)
Chrysokeras (110°, −50°)
Cimmerium Mare (220°, −20°)
Claritas (110°, −35°)
Copais Palus (280°, +55°)
Coprates (65°, −15°)
Cyclopia (230°, −5°)
Cydonia (0°, +40°)
Deltoton Sinus (305°, −4°)
Deucalionis Regio (340°, −15°)
Deuteronilus (0°, +35°)
Diacria (180°, +50°)
Dioscuria (320°, +50°)
Edom (345°, 0°)
Electris (190°, −45°)
Elysium (210°, +25°)
Eridania (220°, −45°)
Erythraeum Mare (40°, −25°)
Eunostos (220°, +22°)
Euphrates (335°, +20°)
Gehon (0°, +15°)
Hadriacum Mare (270°, −40°)
Hellas (290°, −40°)
Hellespontica Depressio (340°, −6°)
Hellespontus (325°, −50°)
Hesperia (240°, −20°)
Hiddekel (345°, +15°)
Hyperboreus Lacus (60°, +75°)
Iapygia (295°, −20°)
Icaria (130°, −40°)
Isidis Regio (275°, +20°)
Ismenius Lacus (330°, +40°)
Jamuna (40°, +10°)
Juventae Fons (63°, −5°)
Laestrygon (200°, 0°)
Lemuria (200°, +70°)
Libya (270°, 0°)
Lunae Lacus (65°, +15°)
Margaritifer Sinus (25°, −10°)
Memnonia (150°, −20°)
Meroe (285°, +35°)
Meridiani Sinus (0°, −5°)
Moab (350°, +20°)
Moeris Lacus (270°, +8°)
Nectar (72°, −28°)
Neith Regio (270°, +35°)
Nepenthes (260°, +20°)
Nereidum Fretum (55°, −45°)
Niliacus Lacus (30°, +30°)
Nilokeras (55°, +30°)
Nilosyrtis (290°, +42°)
Nix Olympica (130°, +20°)
Noachis (330°, −45°)
Ogygis Regio (65°, −45°)
Olympia (200°, +80°)
Ophir (65°, −10°)
Ortygia (0°, +60°)
Oxia Palus (18°, +8°)
Oxus (10°, +20°)
Panchaia (200°, +60°)
Pandorae Fretum (340°, −25°)
Phaethontis (155°, −50°)
Phison (320°, +20°)
Phlegra (190°, +30°)
Phoenicis Lacus (110°, −12°)
Phrixi Regio (70°, −40°)
Promethei Sinus (280°, −65°)
Propontis (185°, +45°)
Protei Regio (50°, −23°)
Protonilus (315°, +42°)
Pyrrhae Regio (38°, −15°)
Sabaeus Sinus (340°, −8°)
Scandia (150°, +60°)
Serpentis Mare (320°, −30°)
Sinai (70°, −20°)
Sirenum Mare (155°, −30°)
Sithonius Lacus (245°, +45°)
Solis Lacus (90°, −28°)
Styx (200°, +30°)
Syria (100°, −20°)
Syrtis Major (290°, +10°)
Tanais (70°, +50°)
Tempe (70°, +40°)
Thaumasia (85°, −35°)
Thoth (255°, +30°)
Thyle I (180°, −70°)
Thyle II (230°, −70°)
Thymiamata (10°, +10°)
Tithonius Lacus (85°, −5°)
Tractus Albus (80°, +30°)
Trinacria (268°, −25°)
Trivium Charontis (198°, +20°)
Tyrrhenum Mare (255°, −20°)
Uchronia (260°, +70°)
Umbra (290°, +50°)
Utopia (250°, +50°)
Vulcani Pelagus (15°, −35°)
Xanthe (50°, +10°)
Yaonis Regio (320°, −40°)
Zephyria (195°, 0°)

The galaxy NGC 4835, photographed with the 74-inch Radcliffe Observatory telescope. The blue-light picture at the left was taken without a filter on an Eastman 103a-O plate, exposed for one hour on June 6, 1956. At the right is a 90-minute exposure in red light, made with a 103a-E plate behind an Ilford 205 filter, on July 2, 1956. Comparison of the pictures indicates that the high-contrast details are relatively blue in color.

Among Southern Galaxies—X

THESE three pictures conclude the series begun in February, 1958, of reproductions from the Cape Photographic Atlas of Southern Galaxies. Two of these views depict NGC 4835, and the facing one is of NGC 1365.

NGC 4835, shown in blue and red light at the top of this page, is so strongly foreshortened that it is rather difficult to classify, though David S. Evans assigns it to type Sb. This kind of system is not uncommon — a spiral structure defined by discrete blobs of luminosity separated by strongly contrasting dark lanes, the whole surrounded by much fainter arms.

The system covers a sky area 3.0 by 0.6 minutes of arc. It is located in Centaurus at right ascension $12^h\ 55^m.3$, declination $-45°\ 59'$ (1950 co-ordinates), and is plotted in the Skalnate Pleso *Atlas of the Heavens*. The galaxy is about 16 degrees from the central line of the Milky Way, in a latitude so low that considerable light absorption is probable. Its magnitude is given as 12.5 in the Shapley-Ames catalogue.

This month's feature picture is of NGC 1365, a magnificent barred spiral and one of the most conspicuous members of the Fornax cluster. However, the distance is probably of the order of 20 million light-years. Thus, this system may be in front of the Fornax group rather than in it, according to G. de Vaucouleurs.

Located at $3^h\ 31^m.8$, $-36°\ 18'$, about 53 degrees below the galactic plane, NGC 1365 is a large, typical barred spiral of intermediate type SB(s)b, according to the de Vaucouleurs classification system described on page 582 of the October, 1957, issue. The bar is foreshortened, since the plane of the spiral is inclined to our line of sight.

Note the characteristic pattern of dark lanes in the lens and the very bright nucleus, where short exposures disclose an innermost spiral pattern of bright and dark matter. The spiral arms are partly resolved into stars of the 19th magnitude or fainter, with many brighter emission knots. (For a low-resolution photograph taken with the 30-inch reflector at Mount Stromlo Observatory, see page 522 of the September, 1957, issue.)

In his list of the 20 bright southern galaxies (page 525, September, 1957), Dr. de Vaucouleurs gives the total photographic magnitude of NGC 1365 as 9.8, compared to 11.2 assigned in the Shapley-Ames catalogue. The galaxy's inner parts measure 4.8 by 3.3 minutes of arc; the over-all size is 11.7 by 6.8 minutes.

The spectrum of NGC 1365 has been observed at Mount Stromlo Observatory, but the Doppler red shift is still unknown.

The 24 photographs comprising the first part of the Cape Photographic Atlas of Southern Galaxies have been reproduced by permission of R. H. Stoy, director of the Royal Cape Observatory. A complete set, in which each 10-by-12-inch print is mounted on heavy cardboard with photographic exposure data and descriptive notes on the back by Dr. Evans, may be purchased for £15 directly from the Royal Observatory, Cape of Good Hope, South Africa.

FACING PICTURE: The barred spiral NGC 1365 in Fornax, photographed with the 74-inch reflector at Radcliffe Observatory, Pretoria, South Africa, on October 23, 1954. For this one-hour exposure in blue light, an Eastman 103a-O plate was used without a filter. Note the marked central zigzag, a feature common in barred spirals. The scale is about 2.1 ~~minutes~~ seconds of arc per millimeter. These three pictures are courtesy the Royal Cape Observatory, Union of South Africa.

OBSERVING THE SATELLITES

Twelve Months of Optical Tracking

A DAILY AVERAGE of 20 observational reports from established optical stations throughout the world has come in to the Smithsonian Astrophysical Observatory during the first year of the satellite-tracking program. The number of measurements of positions at known times is considerably greater. Some photographs, for example, may yield dozens of individual observations from a passage.

Volunteer observers at 116 stations in the United States and 122 abroad made 6,816 visual observations of satellites up to October 1, 1958. The 12 Baker-Nunn camera installations over the world secured more than 500 photographs, and many were obtained with other kinds of cameras before the special satellite-tracking instruments went into operation. The banner month was August, 1958, when 1,595 observational reports were received — 1,392 of them by volunteers.

As the table on page 29 shows, most of the visual sightings were of the relatively bright Russian satellites, for they may be seen over a wide range of latitudes. The Baker-Nunn cameras, all situated in low latitudes, have taken about as many photographs of American as of Russian satellites.

Promptness in transmitting observations to the computing center in Cambridge, Massachusetts, is essential to the success of the program, because the orbit of each object is changing, sometimes very rapidly. Virtually all preliminary reports have been received within a few hours of the observation, ordinarily by wire. More complete reports, used for definitive orbit computations, have arrived within days. The rapid and unhindered transmission of this scientific data across most international boundaries has been of the utmost importance to the optical tracking program.

At Cambridge, the stream of optical observational data is processed by a high-speed digital computer. First, a preliminary set of orbital elements is derived for a satellite. Then the computer compares each new observation with the preliminary predictions to screen out grossly erroneous data, and uses the rest to obtain fresh orbital elements. As a rule, such corrected elements are derived twice weekly during the lifetime of each object.

Next, the future path of the satellite is predicted from the improved elements. One of the several present forms of the Smithsonian ephemerides is reproduced here. Search ephemerides of this and other types are distributed to tracking stations for scheduling new observations. As long as a satellite remains aloft, there are many repetitions of this cycle: from observations to corrected orbit elements to new ephemerides to new observations.

SMITHSONIAN ASTROPHYSICAL OBSERVATORY, CAMBRIDGE, MASSACHUSETTS

September 3, 1958

SATELLITE 1958 EPSILON

These predictions for Satellite 1958 Epsilon are based on the following orbital elements:

T_o = Aug. 23.78067, times are in days, U.T.
Right ascension of ascending node = 322°.483 - 3°.562 $(t-T_o)$
Argument of perigee = 129°.470 + 2°.895 $(t-T_o)$
Inclination = 50°.33
Perigee distance = 1.0408 earth's equatorial radii
Time of perigee crossing = Aug. 23.78067 + .07601620N - 8.8 x $10^{-7}N^2$

SATELLITE 1958 EPSILON

EQUATOR S-N			FOR OTHER LATITUDES							
			SOUTH-NORTH				NORTH-SOUTH			
TIME (UT)	LONG. (W)	LAT.	TIME CORR.	LONG. CORR.	HT. (MI)	BEAR. (N-E)	TIME CORR.	LONG. CORR.	HT. (MI)	BEAR. (N-E)
			SEPTEMBER 9, 1958							
1 7	99.8	50	29	-71.7	707	81.2	33	-92.6	571	98.8
2 56	127.3	45	24	-49.4	873	63.0	38	-115.0	427	116.9
4 45	154.9	40	21	-38.5	970	54.6	40	-126.1	353	125.2
6 34	182.4	20	10	-14.9	1209	39.9	48	-150.5	199	139.5
8 22	210.0	0	0	0.	1299	36.5	54	-166.3	162	142.8
10 11	237.5	-20	-10	14.9	1246	39.9	-49	150.2	222	139.5
11 60	265.1	-40	-21	38.5	1032	54.5	-41	125.9	400	125.3
13 49	292.6	-45	-24	49.3	939	62.9	-38	114.8	481	116.9
15 38	320.2	-50	-30	71.5	773	81.2	-34	92.4	634	98.8
17 26	347.7									
19 15	15.3									
21 4	42.8									
22 53	70.4									
			SEPTEMBER 10, 1958							
0 42	97.9	50	29	-71.6	734	81.2	33	-92.5	597	98.8
2 30	125.5	45	24	-49.4	900	62.9	38	-114.9	449	116.9
4 19	153.0	40	21	-38.5	996	54.5	41	-126.0	372	125.2
7 57	208.1	20	10	-14.9	1224	39.9	48	-150.4	208	139.5
9 46	235.7	0	0	0.	1299	36.5	54	-166.2	162	142.8
11 35	263.2	-20	-10	14.9	1229	39.9	-48	150.3	211	139.5
13 23	290.7	-40	-21	38.5	1005	54.5	-41	125.9	379	125.2
15 12	318.3	-45	-24	49.4	910	62.9	-38	114.9	457	116.9
17 1	345.8	-50	-29	71.6	744	81.2	-34	92.5	606	98.8
18 50	13.4									
20 38	40.9									
22 27	68.4									

SITUATION REPORT
SATELLITE 1958 EPSILON
SEPTEMBER 11, 1958
COMPUTED FOR 0 16 UT

INCLINATION	50.33 DEG.
PRECESSION	-3.562 DEG./DAY
NODAL PERIOD	108.77 MIN.
RATE OF CHANGE OF PERIOD	-0.034 MIN./DAY
LATITUDE OF PERIGEE	-1.65 DEG.
ARGUMENT OF PERIGEE	182.14 DEG.
RATE OF CHANGE OF ARGUMENT OF PERIGEE	2.89 DEG./DAY
HEIGHT OF PERIGEE	161.7 MILES
HEIGHT OF APOGEE	1296.9 MILES
RATE OF CHANGE OF HEIGHT OF APOGEE	-1.9 MILES/DAY

An excerpt from a typical ephemeris for a satellite, in this case Explorer IV. In the first two columns, the times and locations of northward crossings of the equator are listed. On September 9th, for example, this first occurs at 1:07 UT, in longitude 99°.8 west. From succeeding columns, the situation at other latitudes may be derived. On the 9th, the first northward crossing of latitude 50° north occurs 29 minutes later, or 1:36 UT, at a longitude 71°.7 farther east, namely 28°.1 west. The height is 707 miles, and the direction of travel 81°.2 east of north. The last four columns apply similarly to southward crossings.

NASA Plans for Space Research

RESPONSIBILITY for America's non-military space research and exploration was transferred to the National Aeronautics and Space Agency (NASA) on October 1st by executive order. This new civilian agency thus assumes control of all scientific satellite programs, including the Navy's Project Vanguard and the Army and Air Force lunar probe experiments.

Its tasks also involve the development of some rockets more powerful than are required by the Department of Defense. These include a million-pound-thrust single-chamber engine, nuclear-powered devices, and rockets powered by exotic fuels.

One of the satellites planned by the NASA will carry a flashing light, so that its location can be observed at the same instant from widely separated tracking stations, for geodetic triangulation. Observations of conventional satellites must be timed by radio time signals, such as

OPTICAL OBSERVATIONS OF SATELLITES*

Satellite	*Name*	*Launched*	*Moonwatch U.S.A.*	*Moonwatch Foreign*	*Visual Total*	*Baker-Nunn*	*Super-Schmidt*	*Camera Total*	*Totals*
1957α	Sputnik I	Oct. 4	524	348	872	6	—	6	878
1957β	Sputnik II	Nov. 3	1380	1017	2397	11	21	32	2429
1958α	Explorer I	Jan. 31	160	129	289	218	4	222	511
1958β	Vanguard I	Mar. 17	15	8	23	—	2	2	25
1958γ	Explorer III	Mar. 26	39	20	59	4	6	10	69
1958δ	Sputnik III	May 15	1992	1049	3041	244	9	253	3294
1958ε	Explorer IV	July 26	100	35	135	52	—	52	187
			4210	2606	6816	535	42	577	7393

*Including observations of carrier rockets and nose cones from October 4, 1957, to October 1, 1958. Visual totals are individual timed positions, while camera totals are for photographs, some containing many exposures. This summary may not be complete.

those broadcast by WWV, but they may be uncertain by 0.002 second or more because the precise path length of the radio waves from the transmitter to the receiver is unknown. During such an interval a five-mile-per-second satellite travels about 50 feet, causing too great an uncertainty for geodetic work. Use of the flashing beacon would permit unambiguous simultaneous observations for triangulation purposes.

Time itself will be investigated in another moonlet proposed by the agency. It would carry an atomic clock, the rate of which depends upon resonance within the atom. The speed of the satellite in its orbit would be great enough to affect the atomic processes and alter the rate of the clock, thereby providing a check on Einstein's theory of relativity.

Upper-air densities, the aurora, the airglow (self-light of the night sky) are all important subjects for future satellite experiments. For the density studies, a metalized inflatable sphere that can attain a diameter of 100 feet will be launched. It will also serve as a radar target for studies of the transmission of radio waves. A scaled-down model of this device was test-fired from Wallops Island, Virginia, on September 11th, but it failed to inflate.

Additional experiments will extend Explorer studies of intense high-altitude cosmic radiation, a potentially serious hazard to manned spaceflight. According to Herbert F. York, chief scientist of the Defense Department's Advanced Research Projects Agency, manned flight above 300 miles may be best attempted from the north or south polar regions, taking advantage of the effect of the earth's magnetic field.

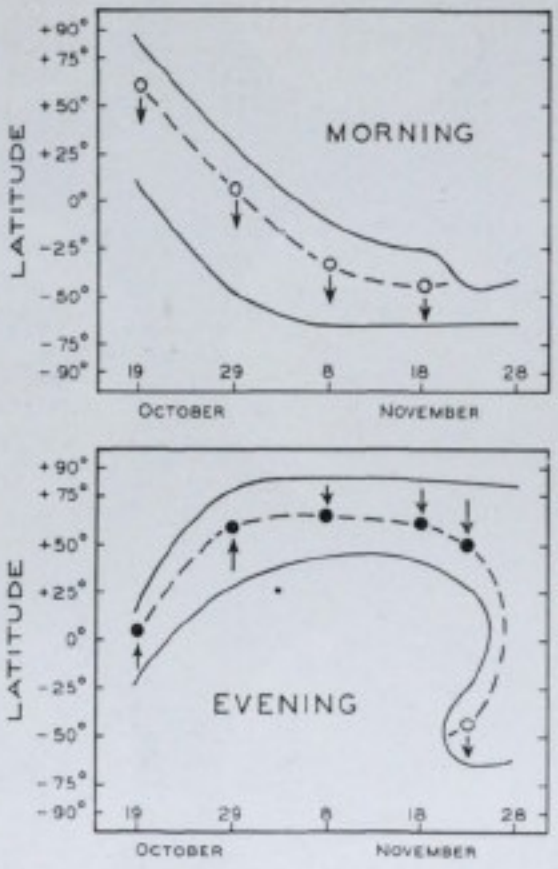
A Short-Lived Vanguard

SEVENTH in the Vanguard program, the satellite launched at 15:38 UT on September 26th from Cape Canaveral, Florida, made "one or at most a limited number of passes around the earth at very low altitudes," according to an announcement by the U. S. Navy. Apparently the rocket did not achieve the height or velocity needed for a sustained orbit, and the satellite was consumed by the resistance of the atmosphere. The 20-inch sphere, weighing 22 pounds, had been instrumented with photocells for observing the earth's cloud cover.

After the launching, Minitrack stations at Grand Turk and at Antigua in the British West Indies, also at Esselen Park in South Africa, received radio signals from the satellite, but none were detected by the San Diego, California, tracking station. A short while later, signals on the satellite's wave length were reported from Ft. Belvoir, Virginia, and from Havana, Cuba.

A few hours later, at 18:13:57 UT, one Moonwatch observer at Bloemfontein, South Africa, saw an object through broken clouds in a direction coinciding with preliminary computations of the orbit by the Naval Research Laboratory. However, there were no further visual sightings, nor were any later radio signals received, in spite of attempts to interrogate the telemetry transmitter within the satellite.

Computations based on radar and radio tracking after rocket burnout show the trajectory was not high enough to produce a permanent orbit.



As satellite 1958δ1, the rocket carrier of Sputnik III, loses altitude rapidly, its period will become progressively shortened in the interval covered by this long-range forecast of visibility zones. On the first date of this chart, apogee height is about 650 miles, perigee about 125. Based on orbital elements for September 30th, this chart extends the one on page 624 of the October issue, where the caption explains the arrows and dots.

Simplified Prediction Manual

A METHOD for predicting the passages of satellites from modified orbital elements has been devised by three agencies that are co-operating in the IGY effort. It is described in a manual entitled *Simplified Satellite Prediction from Modified Orbital Elements,* written by Leonard N. Cormier, Norton Goodwin, and Reginald K. Squires, and published by the National Academy of Sciences-National Research Council.

The authors believe that from both the computation and communication standpoints, the transmission of orbital elements to the observer offers the simplest, most concise arrangement. They believe the observer is then more likely to receive up-to-date information in sufficient time to be conveniently useful.

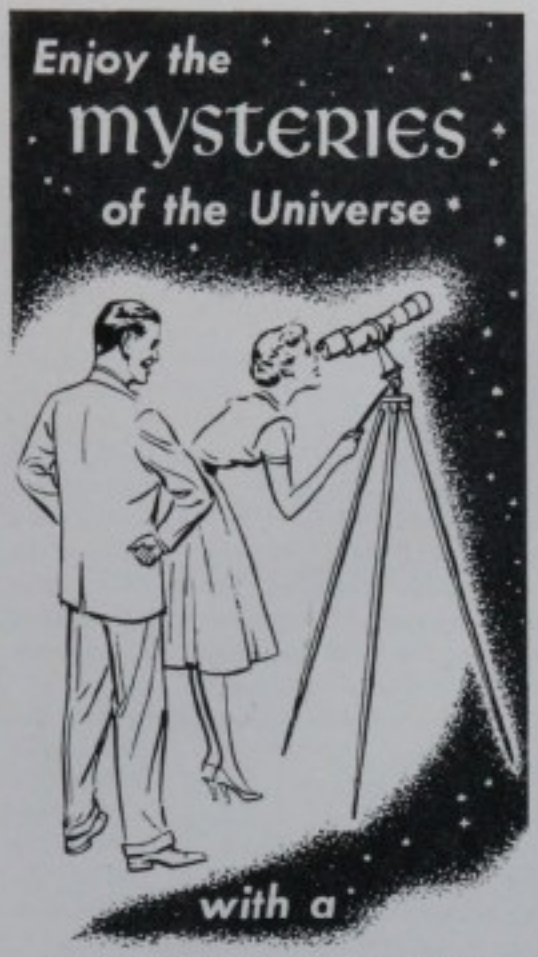
However, many observers are unfamiliar with the computation of orbits. In this manual is presented a scheme whereby a set of modified orbital elements may be handled by anyone who can do arithmetic. In well-prepared schedules, each step of the operation is precisely stated, while space is provided for completing the calculations on the forms.

The procedure permits an observer to "(a) eliminate all but potentially significant observation periods; (b) for any such period, determine the precise time when the satellite will cross (or approach) his latitude circle, the longitude of the crossing (or approach), and the satellite height; and (c) derive from such crossing (or approach) data the azimuth, elevation, and slant range to the satellite for one or more optical observations, or comparable data for radio observations."

The authors have attained the desired simplicity through extensive use of prepared tables and charts which occupy more than half of the 46-page monograph. Even if one prefers algebraic and trigonometric formulae, some of the tables will be useful. In the opinion of this writer, the only real shortcoming of the method is that the angular position of low satellites during close approaches is not given very accurately on the small-scale charts.

The draft edition of the manual, together with 10 short and 30 long computing forms, may be obtained for one dollar a copy from the National Academy of Sciences-National Research Council, 2101 Connecticut Ave., N.W., Washington 25, D. C.

MARSHALL MELIN
Research Station for Satellite Observation
Harvard Observatory
Cambridge 38, Mass.



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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Early Observations of Mars

THIS MONTH the planet Mars will be better placed for telescopic observation than at any other time until 1971. In early June, 1969, the planet will be about as close to the earth as this November, but far south of the celestial equator and therefore low in the sky for most observers in the Northern Hemisphere.

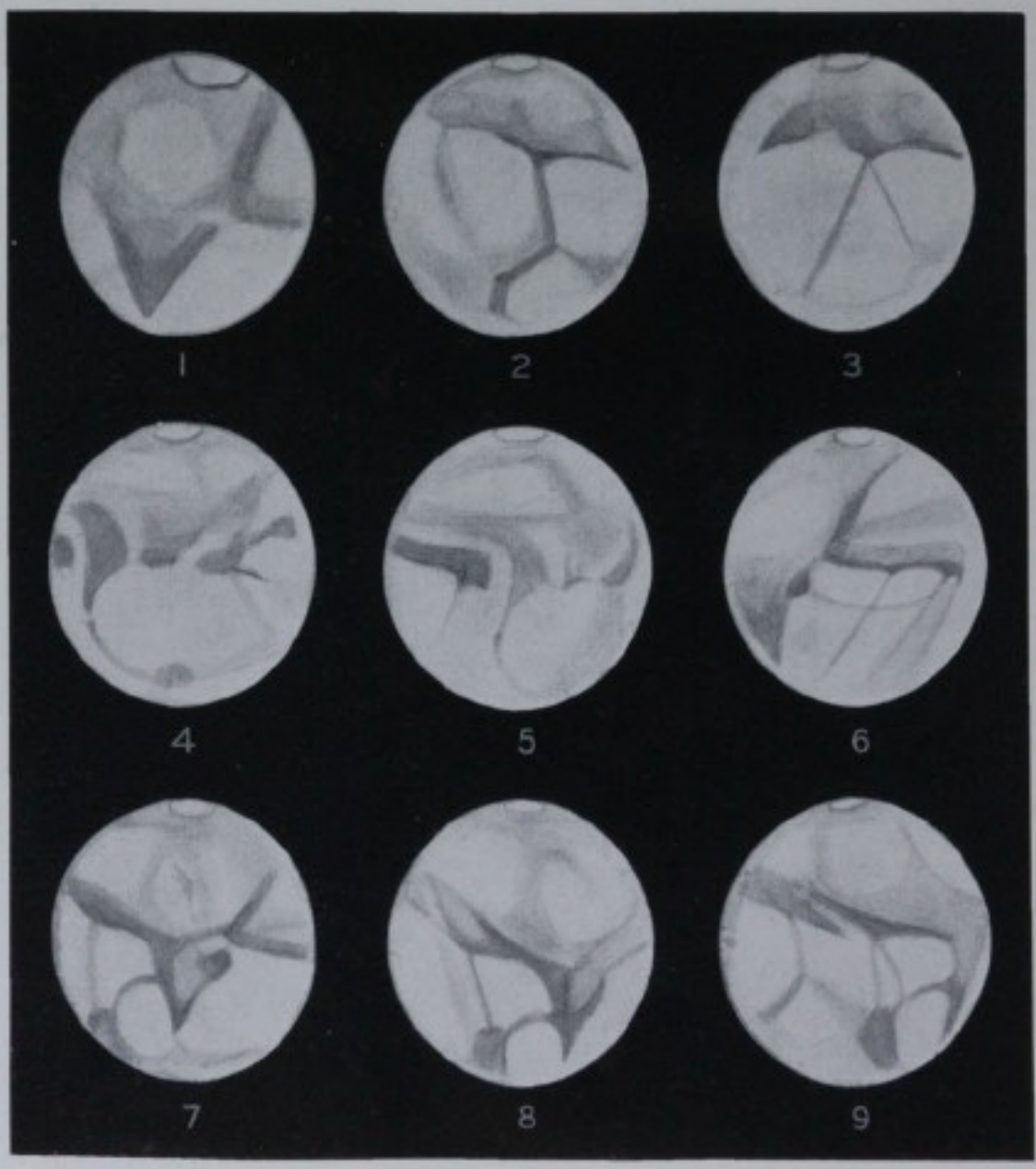
Mars comes to opposition with the sun this November 16th, but least distance from the earth, 45.4 million miles, occurs eight days earlier. In 1956 the closest approach was 35.2 million miles, on September 7th.

This year Mars at its nearest will show a disk 19.2 seconds of arc in diameter, compared with 24.8 in 1956. But its declination will be $+19\frac{1}{2}°$, as against $-10°$ then, placing Mars about 30° higher when on the meridian for Northern Hemisphere observers. This increased altitude will hardly compensate, however, for the disk diameter being 22 per cent less.

Good telescopes of small aperture will show the larger orange deserts and dark "seas" of Mars, but at least a 6-inch telescope is needed for observation of finer details. Most students of Mars agree that a first-rate 10-inch telescope reveals considerably more detail visually than do the best photographs.

From my more than 23 years of observing experience, I have found little difference between good reflectors and good refractors of equal aperture. On nights of better than average seeing, reflectors usually provide better image contrast, with sharpness equal to that in refractors. With only fair seeing, refractors have somewhat steadier and prettier images, but with subdued contrast.

To see much of the Martian surface



Thomas R. Cave, Jr., made these drawings with an 8-inch Newtonian reflector using powers from 360 to 450. For each is given the 1958 date, UT, seeing (0-to-10 scale), Martian diameter and central-meridian longitude: 1, June 21, 11:30, 5-6, 8".1, 302°. 2, Aug. 3, 9:30, 7, 10".4, 204°. 3, Aug. 8, 9:00, 5-7, 10".7, 153°. 4, Aug. 17, 9:00, 7-8, 11".3, 42°. 5, Aug. 21, 8:00, 6-9, 11".7, 13°. 6, Aug. 27, 8:00, 6-8, 12".2, 316°. 7, Aug. 29, 8:20, 4-7, 12".3, 287°. 8, Sept. 1, 8:00, 5-6, 12".4, 261°. 9, Sept. 4, 8:00, 5-7, 12".9, 241°.

Sky and TELESCOPE

NOVEMBER, 1958

Special Supplement

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MAN'S FARTHEST STEP INTO SPACE

The last milestone before flight into interplanetary space was passed successfully on October 12, 1958, when the lunar probe Pioneer traveled to nearly 80,000 miles from earth, one-third of the distance to the moon. When the instrument package separated from the third-stage rocket, it was traveling some 34,400 feet per second, only 850 feet per second too slowly to attain the orbit planned.

This velocity is nearly that of escape from the earth. The narrowness of the margin is the true significance of the Pioneer rocket flight, for here is proof that space-flight is possible with existing multistage rockets, if all their complex components can be made to function together.

In this particular flight, the operations of the parts of the orientation system were not perfectly combined to achieve the delicate balance of speed and direction necessary for the precise orbit desired for the lunar probe. The direction of flight of the first-stage rocket was controlled by gyros, but these had a slightly higher drift rate than expected, with the result that the trajectory was some 3½ degrees too high. This, in turn, meant that the drag by gravity was greater and the vehicle was slowed down. It is believed that most, if not all, of the 850-feet-per-second loss in speed can be accounted for by the difference of 3½ degrees in the trajectory.

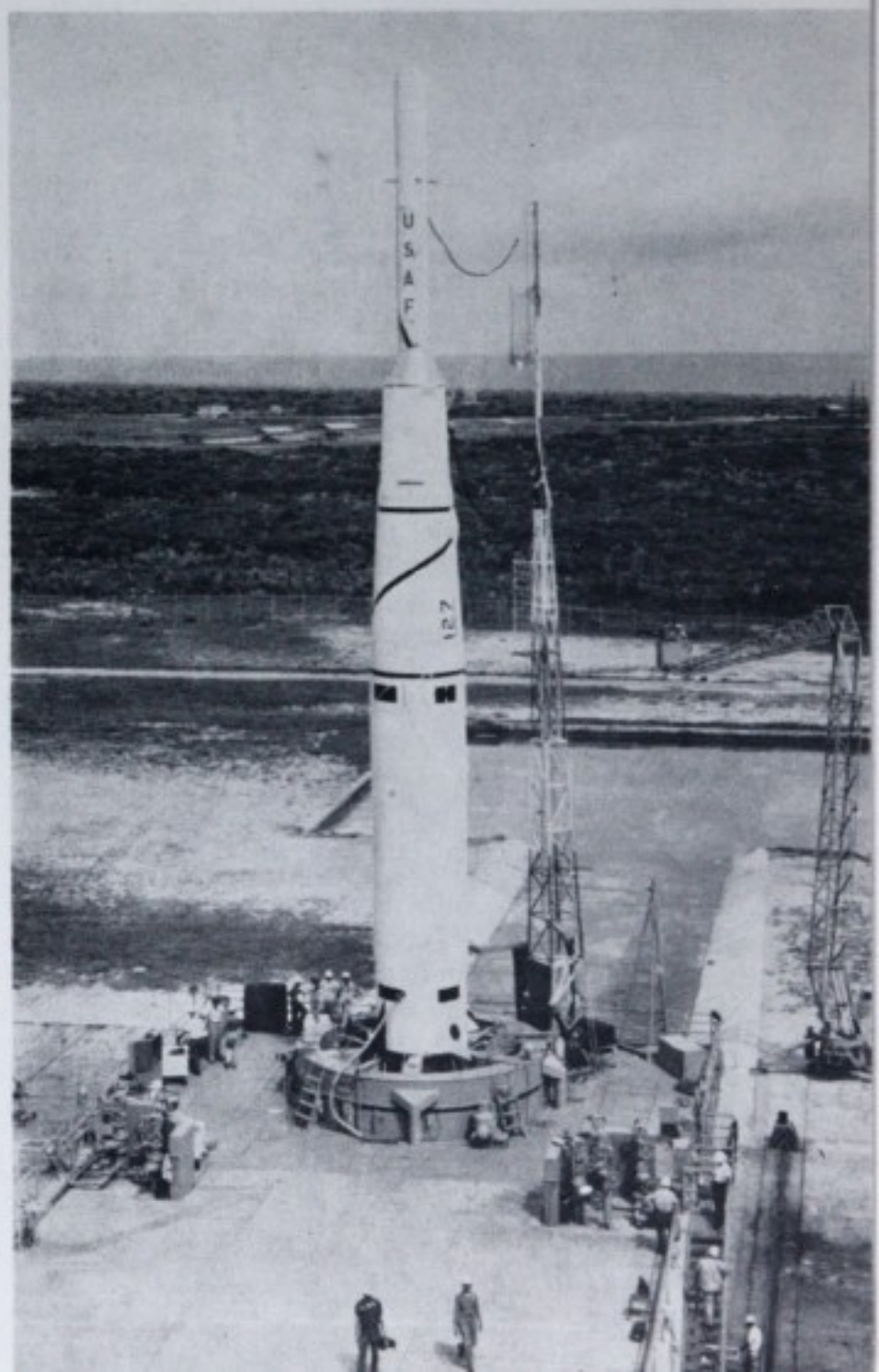
Yet this small difference so reduced the size of the missile's orbit that it attained its apogee point less than a day after launching, whereas its flight to the moon's orbit was expected to require more than 2½ days. The perigee point of the actual Pioneer orbit lay inside the earth, and after some 43 hours of flight it plunged back into the earth's atmosphere, to be destroyed like a meteor. It is believed to have fallen over the South Pacific Ocean.

Thus, this now-historical example demonstrates how critically the size of the orbit followed by a missile cast into space depends on its speed compared with the velocity of escape from the earth. The latter is about 36,700 feet per second at the earth's surface and decreases as the square root of the distance from the earth's center. At the moon's average distance (60 earth radii), the escape velocity is about 4,700 feet per second, while at the distance of 80,000 miles attained by Pioneer it is some 8,200 feet per second.

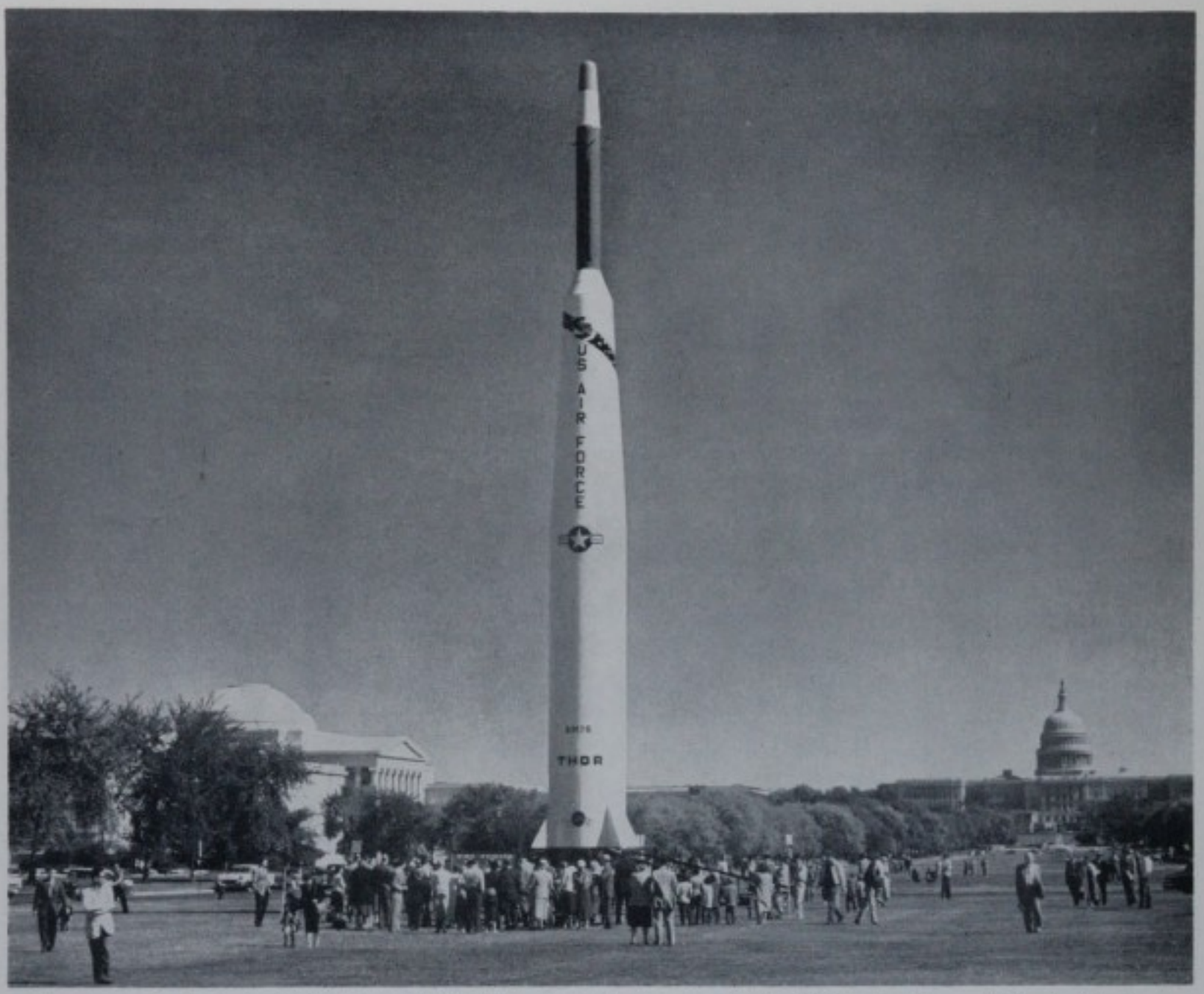
A missile moving more slowly than escape velocity will travel in a closed path — a circle or an ellipse — around the earth's center. Should the perigee distance happen to be less than the earth's radius, the orbit would come within the earth itself, and the body would collide with the surface.

If we consider higher and higher missile speeds — still always less than the velocity of escape — the corresponding orbits are ellipses of greater and greater size. In the following examples, air resistance and similar complications are neglected:

A rocket launched from the surface of the earth at



Amid a flurry of last-minute preparations for takeoff, the Pioneer vehicle, No. 127, rests on its launching pad at the Atlantic Missile Test Range, Cape Canaveral, Florida. Its first three stages are an Air Force Thor intermediate-range ballistic missile, a Navy Vanguard rocket modified for the purpose, and a Navy specially developed solid-propellant rocket. The vehicle was designed to deliver a payload of 83.8 pounds to the vicinity of the moon, and this payload package constituted a fourth stage. In the distance is seen the Atlantic Ocean, over which the rocket's trajectory arched soon after takeoff. U. S. Air Force photograph.



Among people of all ages in Washington, D. C., interest in their government's spaceflight projects is very high. On Saturday, October 11th, as soon as the Pioneer lunar probe was launched, the Air Force erected this full-scale model, about 90 feet tall, on the Mall midway between the Capitol and the Washington Monument. In this view of the Columbus Day crowd of sightseers the Capitol is seen at the right and the National Gallery of Art at the left. Sky and Telescope *photograph.*

0.9 times escape velocity will move in an elliptical orbit whose longest axis is 5.26 earth radii (about 21,000 miles). But for 0.99, 0.999, and 0.9999 times escape velocity, the long axis of the orbit is 50, 500, and 5,000 earth radii, respectively. If the initial velocity were exactly that of escape, the body would travel outward on an open, parabolic orbit of infinite size, never to return. At still higher launching velocities, the trajectory would be a hyperbola, also of infinite size. The significant point, in relation to Pioneer, is how very sensitive the apogee distance is to initial velocity.

Pioneer Research Program

The exciting range of astronomical observations and experiments that will become possible when rockets can circle the moon or land on it has already been surveyed on page 333 of the May issue. Two specifically lunar observations were intended for Pioneer.

One was the measurement of the moon's magnetic field, whose intensity is entirely a matter of conjecture at present. The other project was to scan the moon's surface with an infrared-sensitive television device, from whose telemetered signals a crude map of the invisible side of the moon could be constructed.

For this observation, the far side of the moon should be facing the sun, and this was the case when Pioneer was launched, as the lunar phase in mid-October was just past new. While there is no obvious reason for expecting that the averted face of the moon differs significantly from the visible one, the possibility of some novel finding on the nearly six million square miles of wholly unexplored lunar surface has a strong appeal.

Additional experiments for the October flight were extensions of those already carried out by artificial satellites, but at much greater distances from the earth than ever before. The instrument package of Pioneer carried gauges for recording the impacts of micrometeorites. However, the telemetered counts were so few as to suggest that this part of the equipment did not function properly.

The missile's radio reported the change of temperature

of the interior of the instrument package. This was 71° Fahrenheit at launching, but dropped gradually until it became stabilized at about 35°. The intended temperature was 50° to 60°, and apparently this difference affected the batteries inside the case, frustrating the attempts to fire the last-stage retro-rocket by radio command.

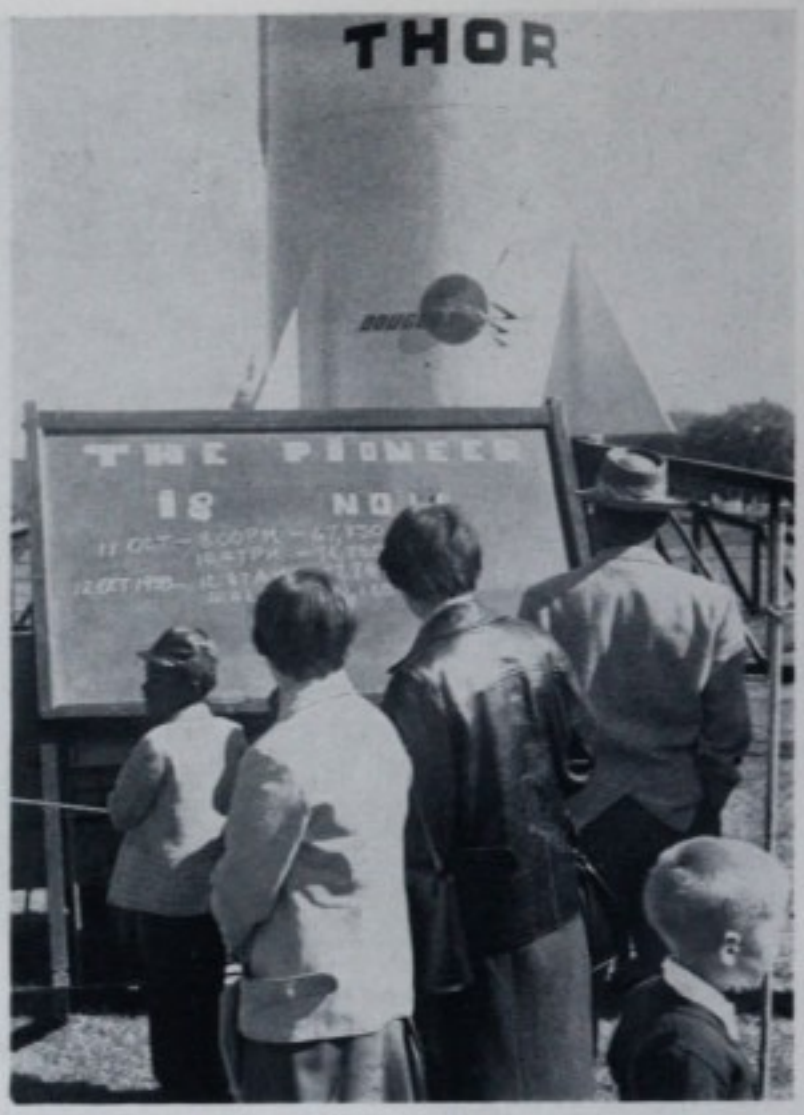
During its 80,000-mile ascent, Pioneer gathered important new data on the high layer of intense radiation discovered earlier this year by the Explorer satellites (see *Sky and Telescope,* June, 1958, page 398). The radiation level indicated by the satellite observations, about two roentgens per hour at elevations around 2,000 miles, seems very hazardous to manned spaceflight. (The maximum safe level permitted for workers in atomic-energy industries is 0.3 roentgen per week.)

Preliminary analysis of the telemetered records of Pioneer suggests that the level of intensity rises to four roentgens per hour at 5,000 miles and then decreases, becoming three at 10,000 miles, and two at 17,000 miles above the earth's surface. Further observations of this kind are needed.

Lunar Probe Launching Times

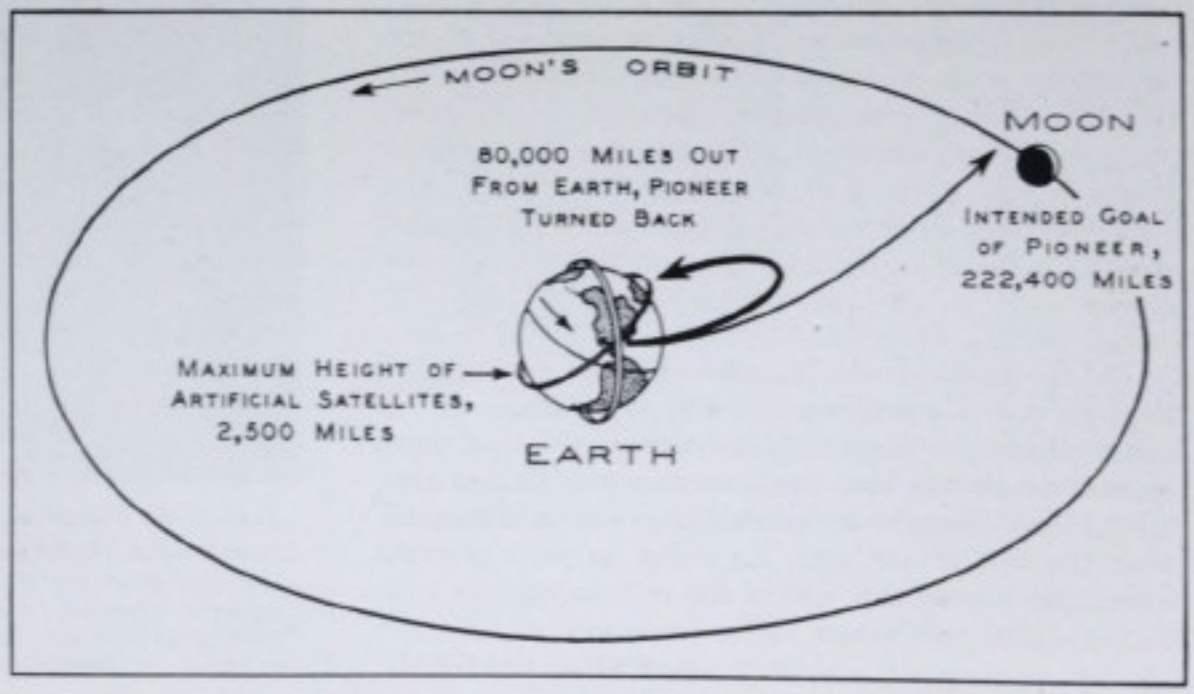
Sometimes it is supposed that the phase and distance of the moon are the primary factors in determining when to launch a rocket to the moon. Although the phase depends on the relative positions of the earth, moon, and sun, it is only a secondary consideration, since the gravitational effects of the earth and moon predominate along the path to be taken by the missile. The sun's influence may be readily compensated for in planning the trajectory. The exact distance of the moon at the time of interception is important principally in the timing of events in the vehicle's flight plan.

The factors that decisively affect the time of launching were discussed on page 625 of the October issue of *Sky and Telescope,* where it was shown that a favorable situation at Cape Canaveral occurs when the moon is crossing the earth's equatorial plane in a southward direction, and continues for about three days thereafter. A narrow limit on the time of day best for launching is set by the orientation required for the retro-rocket, and by the desire to utilize at least part of the earth's rotational speed (910 miles per hour eastward at Cape Canaveral).



A closeup of the base of the Pioneer model that was set up on the Mall in Washington, D. C. Here the blackboard is seen on which the progress of the actual Pioneer during Sunday, October 12th, was posted, for the benefit of the eager onlookers. Sky and Telescope *photograph.*

On August 17th, the launching of a lunar vehicle was attempted, but it exploded 77 seconds after takeoff. This was about an hour before moonrise at Cape Canaveral, the local hour angle of the moon being 106.7 degrees east of the meridian. Therefore, in the October article



Artificial satellite orbits are seen to be very near the earth compared with the orbit of the moon and the path of the first Pioneer. Even previous rocket flights to the highest altitudes, some 4,000 miles above the earth's surface, went out only one-tenth as far from the earth's center. In this sketch, perspective reveals some of the sunlit side of the moon, but it was at the new phase on October 12th, so only its dark side was facing the earth.

continuous wavering note, similar to those they had received in the past from all the American satellites on 108 megacycles. At 4:46, Mr. McCracken went outside with binoculars for a visual observation.

To his surprise, with the naked eye he saw in the southeast a small white cloud, about 20 degrees above the horizon. Shining in a perfectly clear sky, it was in total brightness like a 2nd-magnitude star. Its diameter of several degrees was increasing rapidly. Mr. McCracken believes the phenomenon resulted from the explosion of the first-stage rocket as it re-entered the lower atmosphere; he saw something falling earthward below this cloud, presumably remnants of the first stage.

When Mr. Wright and his wife came out to see the cloud, a comet-like object was visible in binoculars, moving toward the eastern horizon. This was probably the missile, the later stages of which were still firing as it rose into space. The entire visual observing sequence lasted about four or five minutes. The sighting azimuths and altitudes were consistent with the course of the Pioneer vehicle and with the distance from Washington, D. C., to Cape Canaveral.

The spectacular ascent of the Pioneer rocket was seen by the passengers and crew of a Northeast Airlines Boston-to-Miami plane. The DC-6B Sunliner, with 69 persons aboard, was flying at 18,000 feet about 85 miles east of Charleston, South Carolina, at the moment of launching.

Payload Instrumentation

Pioneer was fitted with a complex array of electronic instruments in order to gather and send to earth different kinds of information. The numbers in the accompanying Space Technology Laboratory diagram indicate some important parts, which may be described under the following headings:

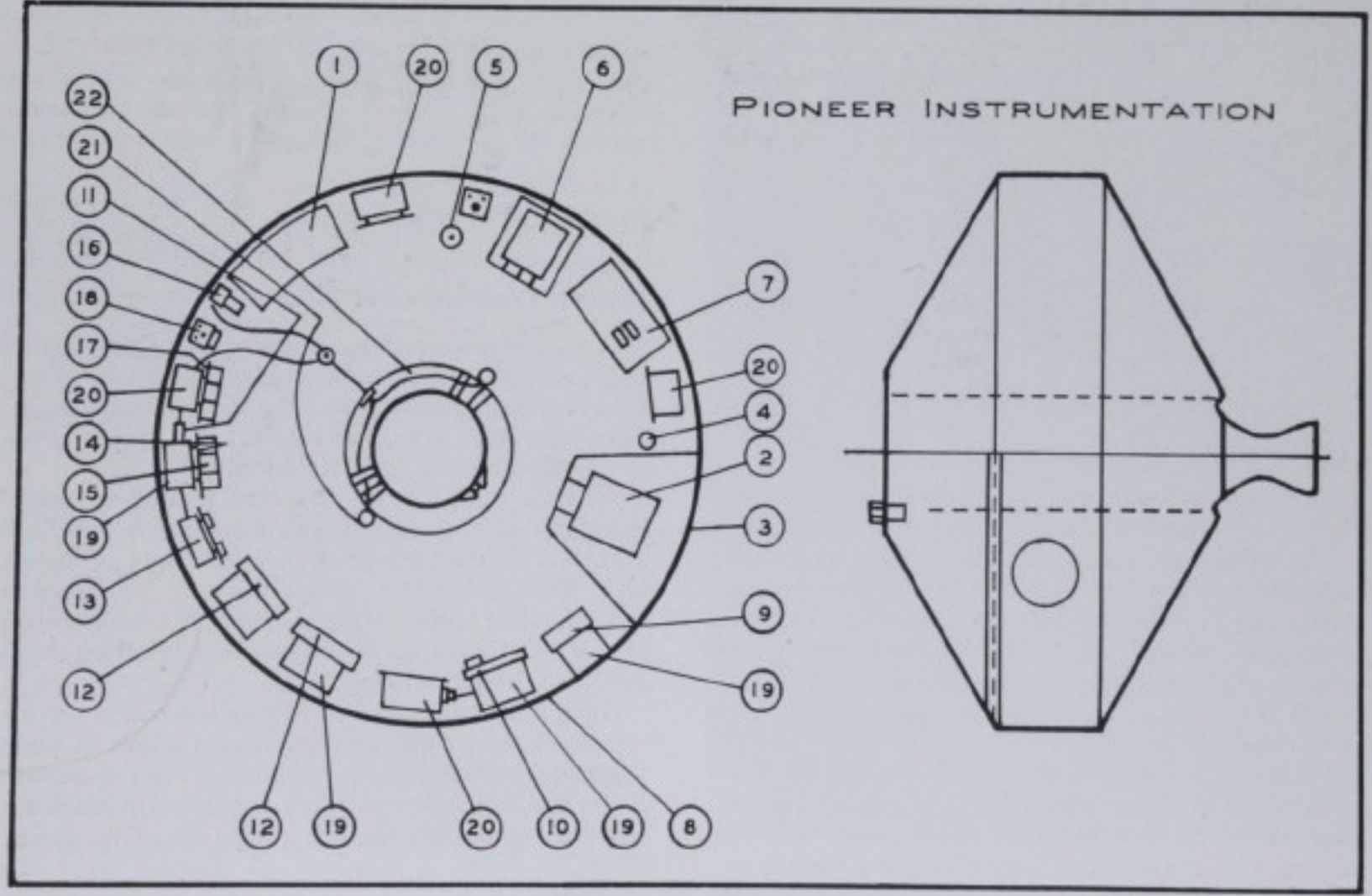
Command Receiver. Instructions to the instrument package from the earth, sent by means of the radar used to measure the Doppler effect in the motion of the vehicle, were received by unit **1.**

Television Apparatus. For infrared scanning of the moon's surface, a television system was employed, consisting of an optical unit **2,** scanning window **3,** driver **4,** final amplifier **5,** and a converter **6** to change the low-voltage direct current supplied by the battery pack and terminal board **7** to high-voltage direct current.

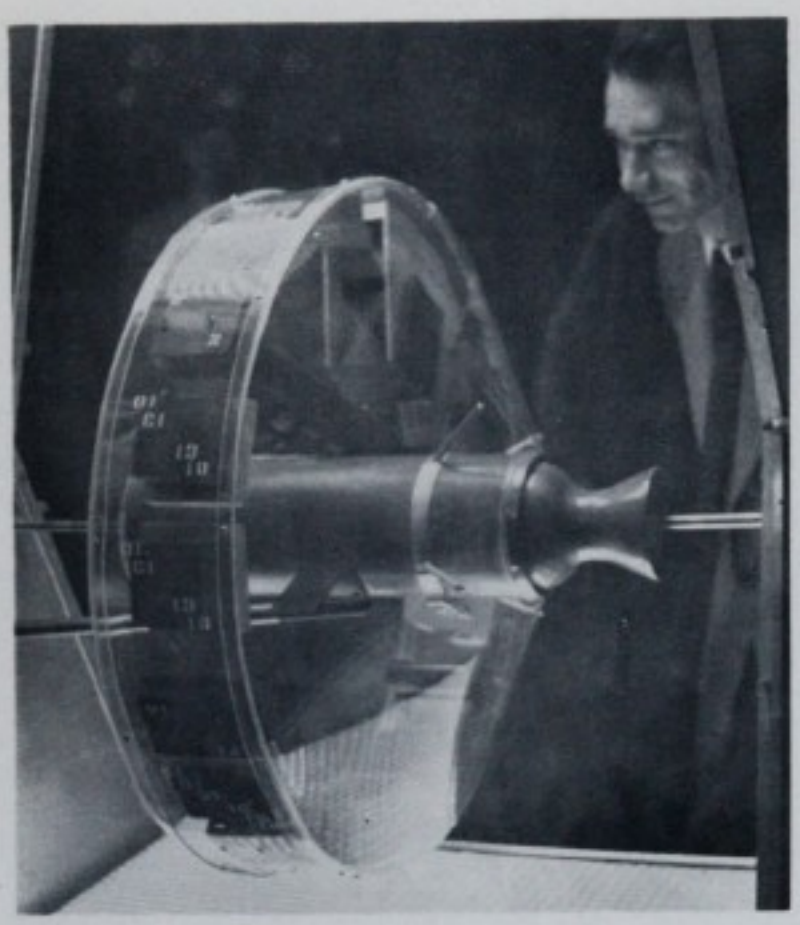
Micrometeorites. Very small particles in space striking the diaphragm 8 of the microphone produced a signal which was amplified at 9 and used to change the signal produced by the subcarrier oscillators **10.**

Magnetometer. To measure the magnetic fields of the earth and moon, the magnetometer consisted of a sensor coil **11,** an amplifier **12,** and a set of subcarrier oscillators **13.**

Compartment Temperature. Sensing devices for meas-



Spaceflight demands that instruments and power supplies be as light and compact as possible. The manner in which the Space Technology Laboratory of the Ramo-Wooldridge Corporation arranged the components of Pioneer is shown by this diagram. At the right is a side view of the instrument compartment and retro-rocket nozzle. Compare the pictures on the facing page with this diagram, which was included in a public exhibit in the Pentagon building, Department of Defense.



This model of the instrument package was designed and set up in the Pentagon public lobby by the Orientation Group, Wright-Patterson Air Force Base. Sky and Telescope *photo.*

uring the compartment temperature actuated another subcarrier oscillator **14**.

Telemetry to Earth. All of the information from the subcarrier oscillators then passed through the low-pass filters **15**, diplexer **16**, and multiplexer **17** to the telemetry transmitter **18**, which was powered by a battery **19** and removable extra-life batteries **20**. The final signal was fed to the telemetry antenna through connection **21**.

Retro-Rocket. If the probe had reached the vicinity of the moon, a rocket fitted in the center of the instrument package would have been fired to slow its motion in order to permit it to circle the moon. The damper ring **22** isolated the instrument chamber from the retro-rocket. Not shown are a pressure-sensing device in the rocket chamber, designed to indicate that this stage had fired, and a spin-rate sensor.

Sterile Lunar Probes

The instrument packages of Pioneer and its ill-fated August 17th predecessor were sterilized chemically and, for the later vehicle, with intense radiation. This step, taken in accordance with international agreement, was to prevent chemical, nuclear, or biological contamination of the moon that could hamper scientific exploration of our satellite.

For example, unless such precautions were followed, it would never be certain whether any large organic molecules that might be found on the moon were not brought by terrestrial missiles. Similarly, a nuclear explosion on the moon might make it impossible for a future expedition to determine the ages of lunar rocks by measuring their radioactivity. Also, a "soft" lunar landing, in which a vehicle would spend tons of fuel for braking, could so contaminate the tenuous trace of lunar atmosphere that its true composition would remain undiscoverable.

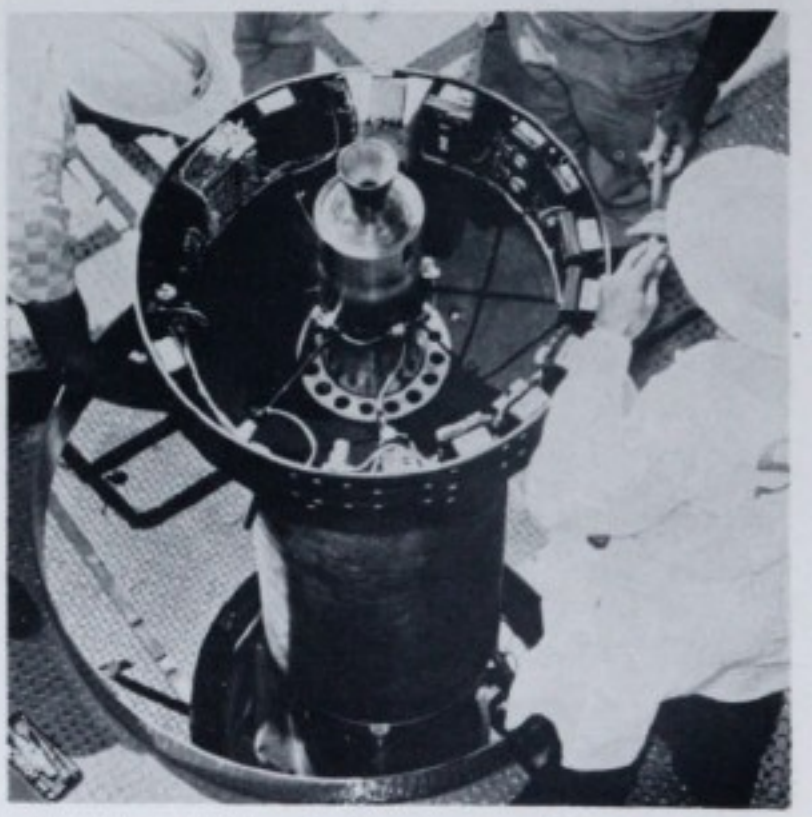
Procedures to avoid spoiling the moon for future scientific purposes have been formulated by the Committee on Contamination by Extraterrestrial Exploration (CETEX). This group, which is affiliated with the International Council of Scientific Unions, met in Holland during May, and at Washington, D. C., in October.

Tracking the Probe

One of the most impressive aspects of the October 11th performance was the excellent co-ordination among the tracking stations, data analysis center, and news dissemination facilities.

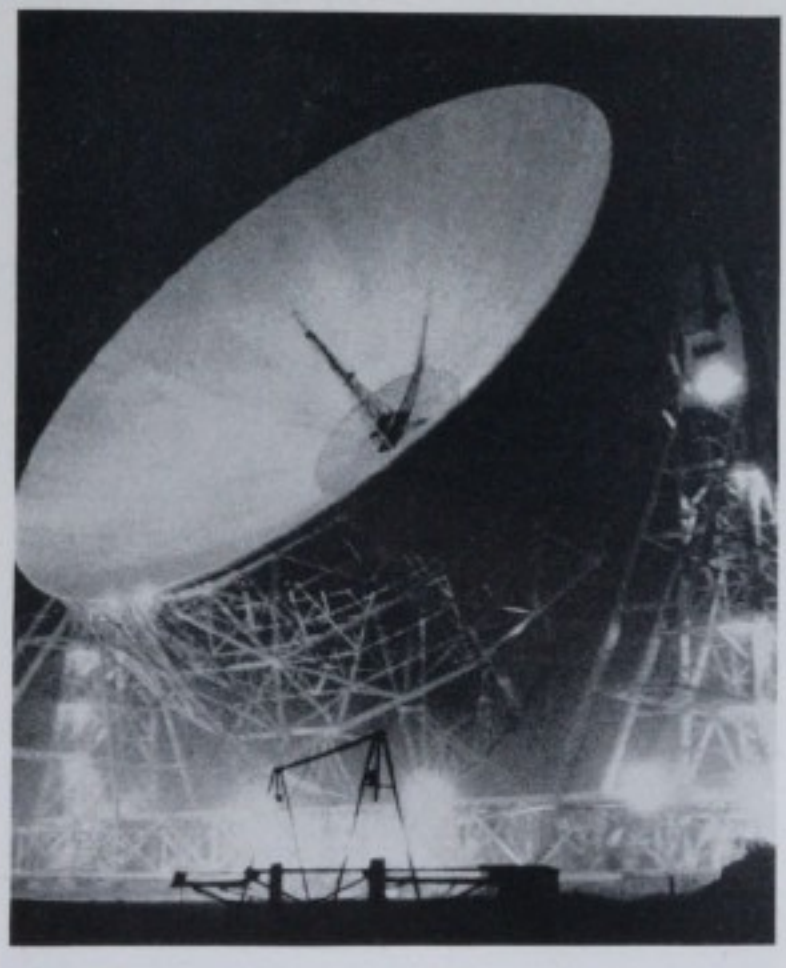
The five primary radio-tracking stations were in continuous two-way teletype contact, with one another and with the data reduction center of Space Technology Laboratory, located at Inglewood, California. The nine Minitrack stations operated by the Naval Research Laboratory reported to their operations center at Cape Canaveral, which relayed the data to the California nerve center.

Because of the unprecedented distance to which the fact-finding missile was to travel, exceptional measures were needed to assure reception of its telemetered signals. Pioneer's transmissions on 108.06 megacycles — the frequency agreed upon by the IGY — were recorded by five of the largest steerable antennas available in the world. These primary stations, which monitored the probe continuously up to 3:46 Universal time on October 13th, minutes before its destruction in the atmosphere, are at Cape Canaveral, Florida; Millstone Hill, in Massachusetts; Jodrell Bank, near Man-



Final phases of the payload-package assembly are under way in this picture, taken from the top of the gantry crane while the rocket was standing on the launching ring. The retro-rocket is pointed upward in the center of the configuration. U. S. Air Force photograph.

The Kanae, Hawaii, installation was one of the five primary tracking stations around the world that were tuned to radio signals from Pioneer. It employs a 60-foot parabolic unit, shown at the left, and four helical antennas (two seen here), each of which consists of four helices that move as a unit in altitude and azimuth. The Hawaiian station was the last to monitor signals upon the descent of Pioneer over the Pacific Ocean on October 13th.



In England the world's largest steerable radio telescope, the 250-foot dish at the Jodrell Bank Experimental Station of the University of Manchester, was used to track the Pioneer in its flight toward the moon and its return to Earth. This night view shows the instrument shortly before its completion almost a year ago.

chester, England; Singapore, British Malaya; and Kanae, Hawaii.

The nine Minitrack stations that helped track Pioneer are located at Ancon, Peru; Antigua, Leeward Islands; Antofogasta and Santiago in Chile; Cotopaxi, Ecuador; Grand Turk, Bahamas; Havana, Cuba; Johannesburg, South Africa; and Woomera, Australia.

The stream of observations of the direction and line-of-sight velocity of Pioneer from these stations flowed into the data reduction center at Inglewood, where the figures were combined and analyzed with an IBM 704 electronic digital computer. From this came the distance and speed values that were so promptly relayed to the public.

The tracking stations made tape recordings of the five channels on which the observations obtained by Pioneer were being telemetered to Earth. Preliminary reports of some of the experiments were quickly made available, in announcements from the Pentagon in Washington, by Louis G. Dunn, president of Space Technology Laboratory, and other spokesmen.

REPORTED DISTANCES OF PIONEER

From the earth's center

Date	*UT*	*Miles*	*Date*	*UT*	*Miles*
Oct. 11	8:42*	4,000	Oct. 11	20:47	65,000
	9:48	12,300	Oct. 12	2:47	74,700
	10:47	20,300		4:47	77,700
	11:47	27,500		8:42	79,100
	14:47	44,400		20:47	54,400
Oct. 11	16:47	52,100	Oct. 13	3:46†	?

*Takeoff. †Last radio observation before final fall.

markings, the amateur needs patience and persistence. Observations should be attempted on every night when seeing conditions are favorable. I find it a good plan to observe the planet for at least 15 minutes before beginning any sketching. This preliminary watch enables the eye to become fully adjusted to the glare of Mars, and makes delicate features easier to detect.

Color filters are helpful, as C. F. Capen, Jr., explained on page 517 of the August issue. I use a Harrison-Duraline #2 RD4 orange filter or a Wratten 23A red filter to increase the visual contrast between the desert and mare regions, and also to lessen irradiation. An Eastman Kodak deep blue filter makes the Martian disk faint, but enhances the polar caps and the mists surrounding them, and helps show white areas near the limb and terminator. It is useful in detecting visually any occurrence of the famous "blue clearing."

Drawings of Mars should be of generous size, with the planet's disk at least two inches in diameter. Beginners often use too small a scale. The drawing should always contain only what is actually seen through the eyepiece, and not what some map may show.

My observations of Mars in 1958 began during the mornings of late April, but the red planet was far from the earth and the brilliant south polar cap was the only conspicuous marking. The telescope used for all my work so far this year is an 8-inch f/7 Newtonian reflector with electric drive, setting circles, and rotating tube.

No drawings were attempted until June 21st, when the angular diameter of Mars was eight seconds. The dark band about the south cap was conspicuous, and the maria appeared of normal contrast (see drawing No. 1).

By the beginning of August, the diameter was 10 seconds, about the minimum for serious study. On several occasions, the extensive areas Hellas and Elysium appeared very white when seen near the limb (2). Mare Cimmerium and Mare Tyrrhenum were very dark along their northern borders (3), while the tip and western side of Syrtis Major were among the darkest portions of the planet (7 and 8). In the northern deserts, Trivium Charontis and Cerberus were very obvious (9), and I even saw them on two nights in early September with a 3¼-inch Brashear refractor at 250x.

From August 10th to about the 22nd, the south cap looked hazy, as if partially mist-covered, but was brilliant though small during the remainder of the month. While the dark band was not seen with certainty after August 10th, on three occasions since September 13th a very narrow dark band was suspected surrounding the tiny remnant of the south polar cap.

The region between longitudes 300° and 60° (6), which includes Sinus Sabaeus, Margaritifer Sinus, and Aurorae Sinus, presented its normal appearance, though on a few mornings the first-mentioned looked lighter than expected. Mare Serpentis and part of Hellespontus have been very dark (6 and 7). Oxia Palus, the large dark oasis north of the tip of Margaritifer Sinus, has been an unusually easy object (5).

More drawings by the author with his 8-inch reflector. For each is given the 1958 date, UT, seeing, power, Martian diameter and central-meridian longitude: 10, Sept. 11, 7:45, 7-8-9, 500x, 13".6, 170°-180°. 11, Sept. 19, 8:45, 5-6, 500x, 14".4, 108°. 12, Sept. 20, 7:45, 8-9, 360x-500x, 14".5, 88°. 13, Sept. 21, 7:30, 8, 360x, 14".6, 67°.

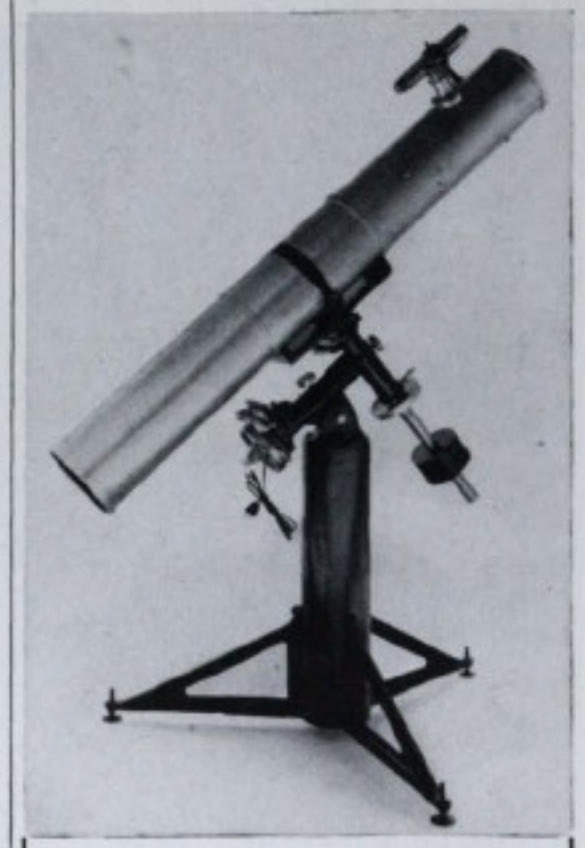
All the "canals" I saw during the early part of the 1958 apparition of Mars seemed rather wide and diffuse, except for those in the desert north of Sinus Sabaeus. These were narrow and dark, being described on August 27th (6) as very well defined.

Of particular interest is Nodus Laocoontis (labeled Thoth on the IAU map on page 23), the major dark area that has grown to prominence in recent years (*Sky and Telescope*, August, 1956, page 442). In 1956, when the north pole of Mars was tilted strongly away from us, this region could be only poorly observed. As this year it is well placed for viewing, it deserves close attention (8 and 9).

Another Martian feature that has changed is Solis Lacus. In 1956 it was a long oval, pointing nearly east-west, but observations this September (11, 12, and 13) indicate it now bends considerably from southern Nectaris. The nearby oasis Juventae Fons was beautifully seen on September 21st and 22nd (12 and 13), a tiny round dot that was certainly the very darkest marking on the surface of Mars.

Near dawn on September 16th, Walter H. Haas reported a large cloud over Ausonia, part of Mare Tyrrhenum, and part of Syrtis Major. Unfortunately, I could not observe this region the next morning. On September 20th (12), I saw a small, very bright projection on the terminator — probably a cloud high in the Martian atmosphere. It was first visible at 7:07 UT, and was very plain at 7:52 when fog over Long Beach, California, halted observation. On the next night, when the same region of Mars was again on the terminator, a close search revealed no trace of this projection.

The blue clearing is the occasional abnormal transparency of the Martian atmosphere at short wave lengths. When it occurs, blue-light views show the surface



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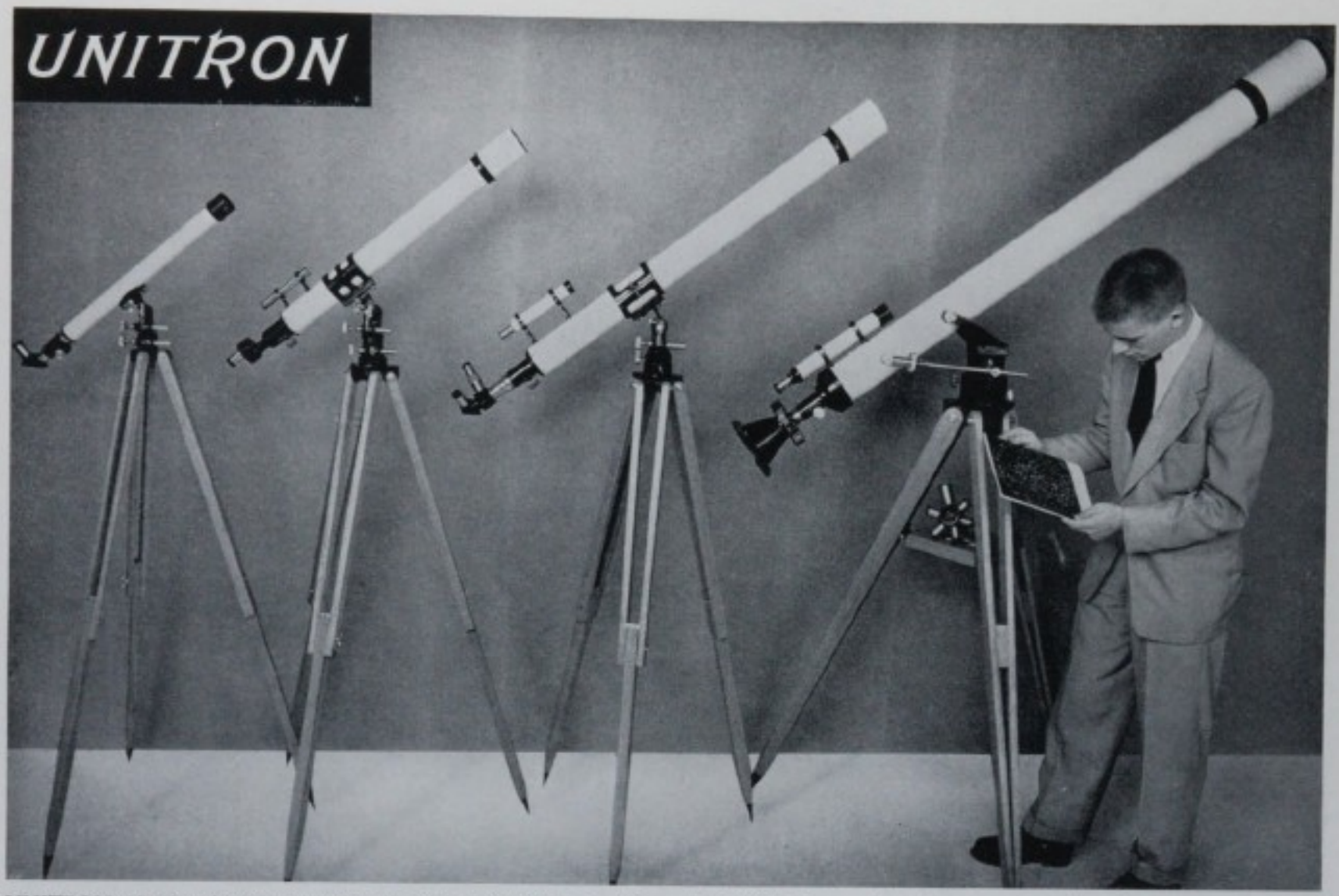
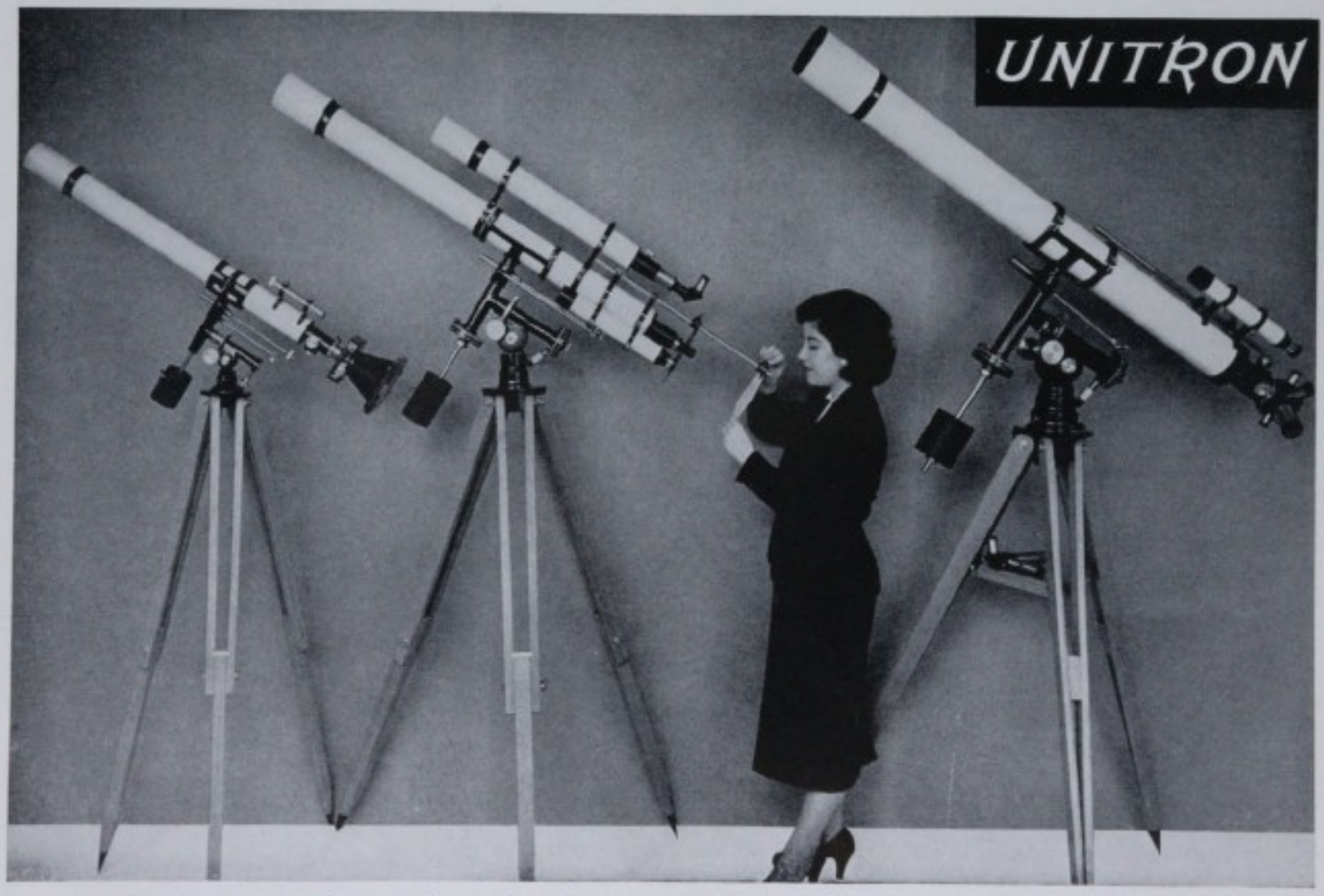


UNITRON Altazimuth Refractors: left to right, 1.6" (with star diagonal), 2.4" (with erecting prism system), 3" (with DUETRON double eyepiece), and 4" (with astro-camera and with UNIHEX on the shelf).



UNITRON Equatorial Refractors: left to right, 2.4" (with astro-camera), 3" Photo-Equatorial (with sun screen), and 4".

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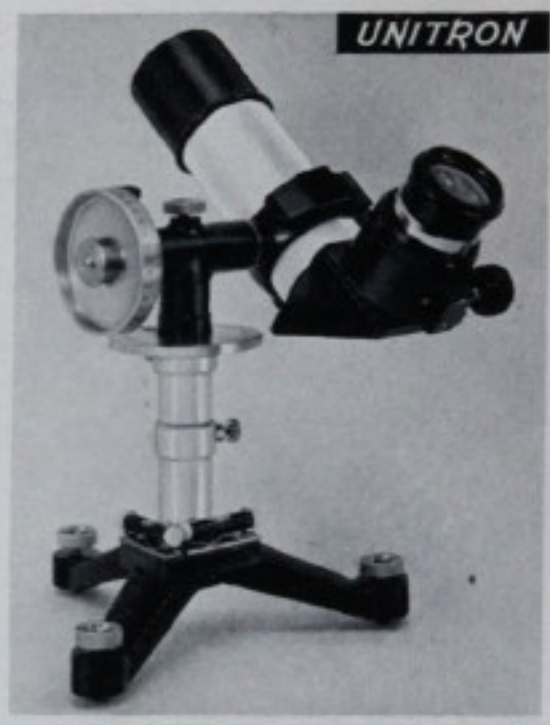

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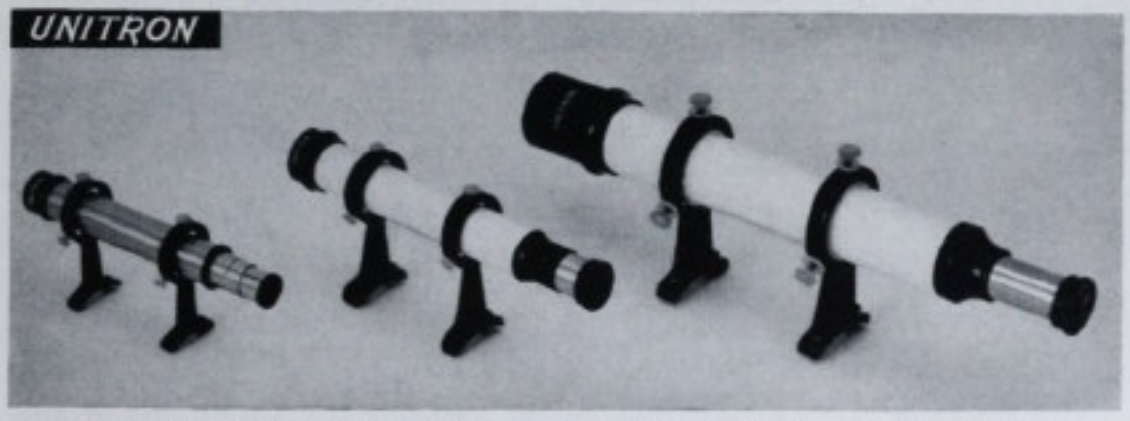

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markings instead of just a featureless disk. Until 1954, the blue clearing was thought to occur only at the time of opposition, but co-operative observations obtained evidence of it on several dates considerably earlier. In 1956 G. de Vaucouleurs, observing in Australia, found that the blue clearing is not always planet-wide, as had been believed, but may occur over only a part of one hemisphere.

Since early August, every night that I observed Mars I inspected the planet through a Kodak deep blue filter to look for the blue clearing. Ordinarily this showed only the south cap and some vague white areas near the north limb. On August 29th I suspected a clearing, for Syrtis Major was faintly visible through the filter. On September 19th and 20th, Solis Lacus and its surroundings were definitely visible in deep blue light, and in the darker mare detail was quite easily seen.

In early September, R. S. Richardson took photographs with the 60-inch Mount Wilson reflector showing definite evidence of a blue clearing, and visual observations of the phenomenon were made by Alika K. Herring of South Gate, California.

The very favorable 1956 opposition of Mars was disappointing to many observers because of the apparent faintness of the dark markings. When Mars was closest to the earth in September that year, much surface detail was obscured by a great yellow cloud, the most extensive and long-lasting in the history of Martian observations. My studies this year consistently show that better views of the dark maria can be expected through the coming autumn and winter months, for in general they appear of normal contrast and intensity.

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DEEP-SKY WONDERS

WHEN cool, crisp November skies roll around, new delights await the amateur. On a clear, moonless night he shows his friends the great spiral galaxy in Andromeda, and perhaps M33 in Triangulum, both described on page 637 last month. The former is an impressive sight in low-power binoculars and telescopes.

While his friends locate the famous Double Cluster in Perseus with the unaided eye, the amateur swings his telescope to it, at right ascension 2h 17m, declination +56° 54′ (1950 co-ordinates). There, in a low-power, wide-field eyepiece, the brilliant double swarm of suns, h and χ Persei, brings exclamations of wonder and appreciation from the viewers.

Next, after a long pause to scan the orange disk of Mars, he turns the telescope to the Pleiades, and puts on his lowest-power ocular. By tradition, the host asks his visitors to make a naked-eye count of the Seven Sisters before looking through the telescope. If the night is extremely clear, he may even glimpse the very faint nebulosity surrounding the star Merope in this open cluster.

But eventually his friends get tired, and go home to the children or television, and the amateur tries a really hard one for himself: the faint spiral galaxy NGC 16, at 0h 06m.5, +27° 27′, just south of Alpha Andromedae. As it is tiny and of the 12th or 13th magnitude, locating this object gives a feeling of accomplishment.

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SUNSPOT NUMBERS

The following American sunspot numbers for August have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

August 1, 240; **2,** 240; **3,** 216; **4,** 178; **5,** 217; **6,** 238; **7,** 235; **8,** 211; **9,** 235; **10,** 240; **11,** 192; **12,** 189; **13,** 180; **14,** 155; **15,** 191; **16,** 198; **17,** 177; **18,** 149; **19,** 136; **20,** 142; **21,** 161; **22,** 174; **23,** 190; **24,** 185; **25,** 195; **26,** 161; **27,** 175; **28,** 184; **29,** 166; **30,** 193; **31,** 209. Mean for August, 192.0.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

September 1, 200; **2,** 221; **3,** 230; **4,** 240; **5,** 206; **6,** 220; **7,** 175; **8,** 160; **9,** 166; **10,** 219; **11,** 245; **12,** 268; **13,** 265; **14,** 233; **15,** 230; **16,** 206; **17,** 189; **18,** 205; **19,** 187; **20,** 163; **21,** 156; **22,** 172; **23,** 175; **24,** 174; **25,** 161; **26,** 169; **27,** 177; **28,** 208; **29,** 218; **30,** 189. Mean for September, 200.9.

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AMATEUR PHOTOGRAPHS OF MARS

DURING the favorable opposition of Mars in 1956, I obtained a number of photographs of the planet with my 12½-inch reflector through a ¼-inch Ramsden eyepiece. One-second exposures were made on Verichrome Pan film, which was developed in Durol 7. The Zeiss-Ikon camera had a delayed-action shutter release, which allowed time for telescope vibrations to die out before each exposure was made.

The first of the two photographs, reproduced below, was taken on August 12, 1956, at 1 a.m. Central standard time, when the longitude of the Martian central meridian was about 306°. Because this was almost a month before the date of opposition, Mars showed a distinct phase, the west (left) limb being unillumi-

nated. The south polar cap is bright and prominent. The dark markings to the left and right of the center of the disk are Syrtis Major and Sabaeus Sinus, respectively.

The picture above was taken on September 19th, at 10 p.m., with Martian longitude 275° on the central meridian. At this time the apparent diameter of Mars was 24 seconds of arc, the planet being so near opposition that the phase was inappreciable. The south polar cap is not detectable. Syrtis Major appears as a large dark triangle in the lower part of the disk, and above it is the conspicuous light region, Hellas.

EVERETT S. OLIVER
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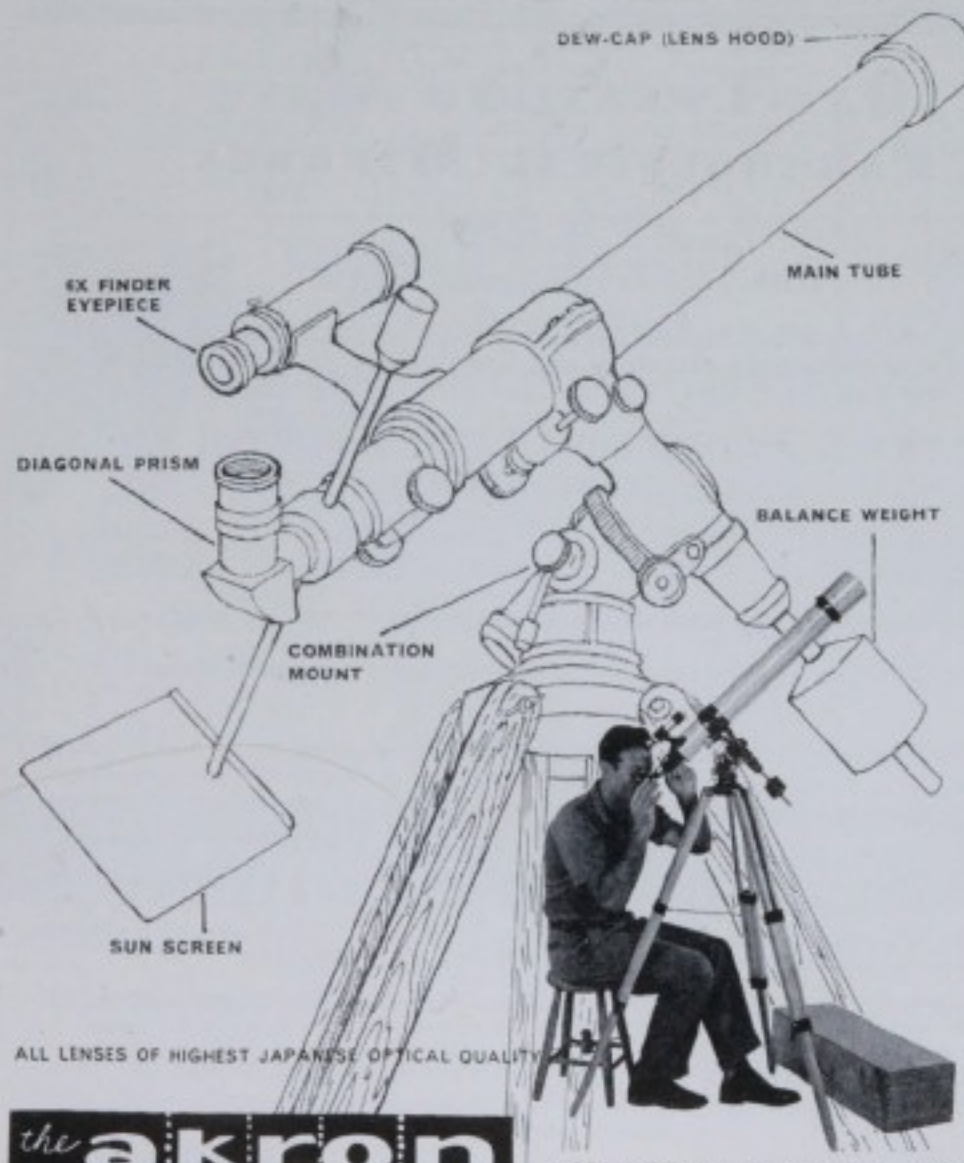

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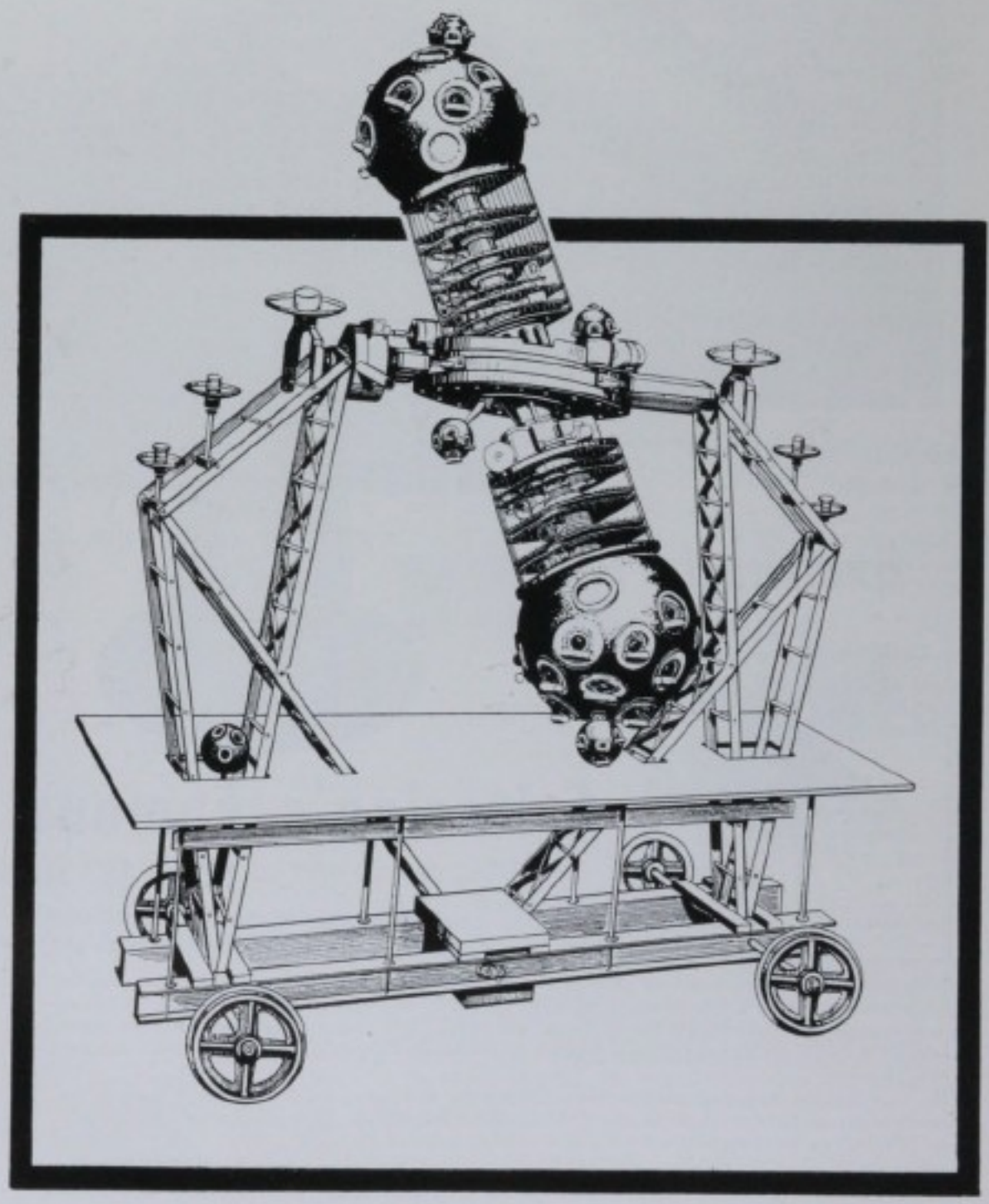

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BOOKS AND THE SKY

OF STARS AND MEN

Harlow Shapley. Beacon Press, Boston, Mass., 1958. 157 pages. $3.50.

A STRONG CASE could be made for the thesis that man's restless intellectual drive is motivated by uncertainty as to his place in the natural scheme. *Of Stars and Men* is Harlow Shapley's appraisal of the horizons that rational man has attained in his quest for perspective and orientation.

Why should a man whose career has been devoted mainly to astronomy be so actively interested in the origin of life and its role in the universe? Without pretending to speak for this book's author, I venture the opinion that he has been motivated, not by a curiosity about the stars and galaxies *per se,* but by that broader concern to know "what is man, and whither are we bound?" Our more impressive lessons in humility and first intimations of cosmic grandeur began with the stars, and astronomy is still a good place to begin if we are looking for perspective.

About three decades ago, Dr. Shapley approached his present theme in *Flights from Chaos,* a small book based on a series of lectures given at the College of the City of New York. To the animate portion of the universe he devoted a remarkable two-paragraph chapter entitled "Note on Organic Colloidal Aggregates." In his latest book, the proportions are interchanged, an up-to-date survey of the inanimate universe serving as background for inquiry into the role of life and intelligence in the physical world.

The author traces the three great adjustments in perspective that man has had to make since his early illiterate cultures. Each of these has required acceptance of a more peripheral position for man, first with the geocentric concept, then the heliocentric system, and lately the galactocentric cosmos.

The fourth adjustment is today's realization that we are not alone in a hostile universe, that the peculiar organization of matter that we call living is as "natural" and pervasive as are the solid, liquid, and gaseous states. The processes by which inanimate matter can be expected to evolve into living organisms have been intimated with sufficient clarity to dispel any need for a miracle to explain the origin of life on earth. Parallel developments in astrophysics indicate that planets are not rare but commonplace.

The inescapable conclusion is that what has happened on earth has happened, and will happen, elsewhere. Although this fourth adjustment deprives man still further of his pretensions to uniqueness, like the earlier shifts of perspective it evokes an awareness of undreamed-of grandeur in which we all participate.

Dr. Shapley supports his position with a comprehensive summary of the fundamental cosmographic information that has accumulated in astronomy, physics, chemistry, geology, biology, and other fields. He deliberately limits his discussion to the physical entities of space, time, matter, and energy as the framework of the cosmos. He traces our orientation in space and time, our comprehension of the structure of matter and the energetic relations among material systems.

Man is fortunate, he points out, to have arrived on an old planet with a telltale past. On a virgin planet without previous life or geological evolution there would be no signposts to mark out the dimension of time. But man is a late-comer on a world already old when the first life began. Everywhere, in the dying radioactivity of the rocks, in the topsy-turvy pages of the book of sediments, in the fossil memories of the living past, we find the long trace of time. Recently, the geological calendar has linked up excitingly with the timetable of stars and galaxies, and half a dozen lines of evidence agree on a crucial time of vast beginnings a very few billion years ago.

Although realizing that life chemistry and structures on some planets may be radically different from those on earth, Dr. Shapley believes life on other worlds depends on the basic compounds of carbon and a few light elements that are the matrix of terrestrial living matter.

Man he recognizes as a creature of remarkable potentiality, because of the greatly specialized development of his brain and his awareness and intelligence. Yet he cautions against attributing too much superiority to man, pointing out the loss of the complex instinctive behavioral wisdom that is so highly developed in many "lower" organisms. He also emphasizes the handicap of man's inferior sensory equipment.

I am inclined to question this assessment of man's position. It is just his lack of highly developed instinctive patterns, I believe, that frees his rational mind and enables the human species to transcend the slow adaptive processes of organic evolution, avoiding physiological specialization with its inexorable penalties.

Man's cognitive equipment, too, may include some unrealized reserves. Dr. Shapley notes that "there are those among us who dream of vestigial or embryonic senses hovering about the human psyche." From one who is trying to evaluate the significance of man in the natural order, this comment seems inadequate to take account of the demonstrations by many quite wakeful investigators of cognitive facilities that are not mediated through any known sensory mechanisms.

On questions of philosophy and religion, the retired Harvard astronomer is frank but circumspect. He dismisses the anthropocentric dogmas of the past as

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irrelevant, but he is equally cool toward instituting new dogmas based on scientific findings. While he constructs his current picture of the cosmos on the framework of space, time, matter, and energy, he doubts that these are enough for a full insight. He suggests the need for a fifth entity, "something that would make click a universe of stars, organisms, and natural laws that otherwise might be clickless." He anticipates also the need for a fifth adjustment in perspective that will transcend the current physical and biological orientations.

"It is my own belief (or is it fancy?) that the central theme of biological existence is to grow in refined complexity, in durability, in adaptability. Man as half beast, half angel, must comply with the biogenetic common law, but he is able to make amendments thereto. . . . It is probable that the men of the future will overcome our shortcomings and build out of our thoughts and acts a finer mental and social structure — one that is in better keeping with Nature's heavy investment in the locally dominant human race."

J. H. RUSH
High Altitude Observatory

PLANETS, STARS AND SPACE

Joseph Miles Chamberlain and **Thomas D. Nicholson.** Creative Educational Society, Mankato, Minn., 1957. 223 pages. $7.50.

ASTRONOMY with a minimum of text and mathematics is the theme of this book. In the introduction, the authors call the photograph one of the wonderful features of modern astronomy, and they use pictures to very good effect. Almost all of the right-hand pages are full-page illustrations of astronomical views through large telescopes, pictures of observatories and instruments, or charts and diagrams to accompany the text.

The first of the book's eight chapters deals with the earth as a planet, its physical dimensions, characteristics, and motions. Such phenomena as northern lights, fireballs, and meteorites, are also discussed. Before they proceed to the other members of the solar system and more distant heavenly bodies, the authors devote a section to modern astronomical instruments.

The moon is then discussed, with inspiring closeup views of its surface. Tides and eclipses are also covered. A chapter tells of the sun as a star and as the center of our planetary system.

There follows a description of the various types of stars and star groups in our own galaxy, the Milky Way. The final chapters concern other galaxies and the constellations.

Because of its "unit" style, the book on the whole may seem disconnected, but this is a valuable feature for the person who must get his reading on the run, so to speak. Each page is a unit, on some specific topic related to the facing picture. With the aid of the comprehensive index, the reader can turn to any subject and find the answers to specific questions, or can study one or more sections as time and inclination permit. The illustrations are in an attractive dark blue, and a maroon cover complements the fine printing.

It is noteworthy that little attention is given to space travel, which is a relief from those recent books that present many pages of imaginative material and artists' drawings with scant regard for facts or reasonable theories.

EDWARD J. NEWMAN
324 W. Yakima Ave.
Yakima, Wash.

FRONTIERS IN SCIENCE

Edward Hutchings, Jr., editor. Basic Books, Inc., New York, 1958. 362 pages. $6.00.

THIRTY ESSAYS by scholars, most of whom have been associated with California Institute of Technology, are collected in this book. The essays are presented under three major headings, biological, physical, and social, and include such widely different topics as the philosophy of laughter and the creation of elements in the interiors of stars.

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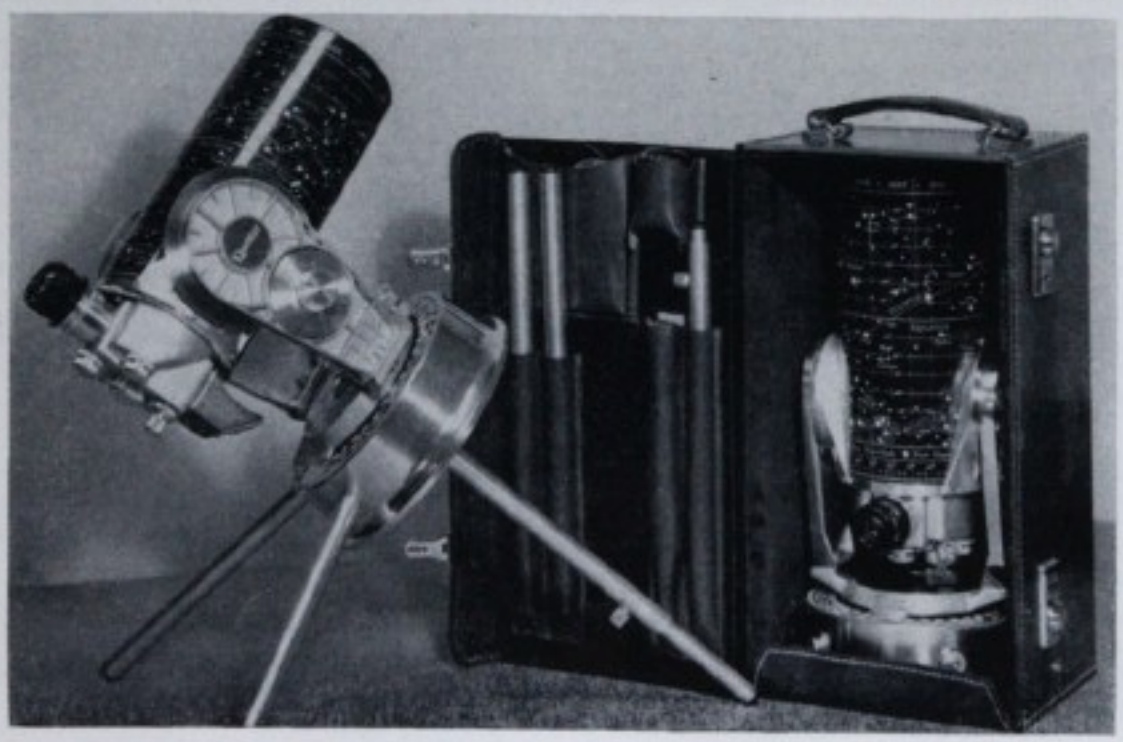

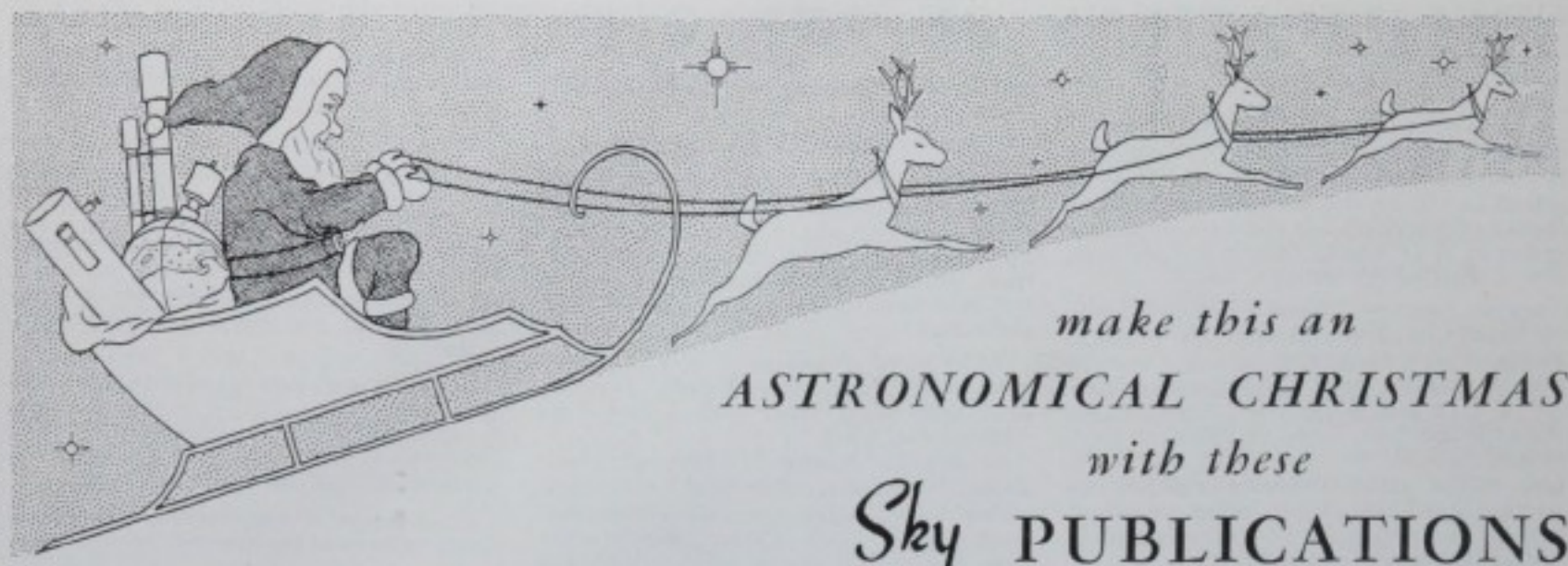

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Spaceflight is printed during October, January, April, and July. Please specify the issue with which your subscription should start. Back issues to Vol. 1, No. 1, October, 1956, are available.

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For the Beginning Observer

This attractive package is designed to help the beginner. **Popular Star Atlas** is a compact, well-bound set of 16 maps, showing stars down to magnitude 5½. **Color Map of the Northern Heavens** is a large wall chart, showing the northern sky to −45° on a polar projection. **Splendors of the Sky** is a 36-page picture book of our neighbors, near and distant, in the universe. Also included is our popular **Lunar Map,** which identifies a large number of features on the moon.

Popular Star Atlas — **Color Map of the Northern Heavens**
Splendors of the Sky — **Lunar Map**

A retail value of $5.00 for **$4.50**

For the Advanced Observer

These three publications belong in all observers' libraries. **Field Edition Atlas of the Heavens** has 16 unbound charts, 12 by 18 inches, showing white stars (to magnitude 7.75) on a black background. **Atlas of the Heavens Catalogue,** with positions for epoch 1950.0, lists stars, clusters, nebulae, planetaries, and galaxies; also includes the Messier list and many useful tables. **Elger's Map of the Moon** is a large, canvas-mounted chart, identifying all the important lunar features, with notes by H. P. Wilkins on 146 of the more interesting areas.

Field Edition Atlas of the Heavens
Atlas of the Heavens Catalogue
Elger's Map of the Moon

A retail value of $13.25 for **$12.00**

For the ATM and Observer

Here are two books for the telescope maker who plans to observe with his completed instrument. **Making Your Own Telescope** tells him how to make and mount a 6-inch reflector at low cost. **Norton's Star Atlas** covers the whole heavens, showing over 9,000 stars to magnitude 6⅓, along with descriptive lists of 500 interesting objects for viewing with the telescope, and useful data on the sun, moon, and planets.

Making Your Own Telescope, by Allyn J. Thompson
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With both amateur and professional astronomers, **Sky Sets I** and **Sky Sets II** have long been favorites. Each set contains 24 large photographs of astronomical wonders, including objects in the solar system and in the Milky Way, portraits of other galaxies, many made with the 200-inch telescope, and drawings of the Hale reflector by Russell W. Porter.

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For All Astronomers

This monumental work belongs on every astronomer's book shelf. **The History of the Telescope** is the first book to tell the full story of the evolution of the telescope, beginning with the crude astronomical instruments of the ancients, to the giants of today. There are 456 pages, including 196 illustrations and extensive references.

The History of the Telescope, by Henry C. King

A retail value of $9.75 for **$7.50**

NOTE: These gift specials are good only in the Western Hemisphere. Offers expire January 31, 1959.

man H. Horowitz traces the history of spontaneous generation, and tells how researchers have projected conditions of the earth's atmosphere back to two billion years ago, at which time, they believe, it consisted of hydrogen, ammonia, methane, and water.

Touching on the problems of feeding the world and of overpopulation, Henry Borsook, a biochemist, argues that present technological advances are sufficient to supply the necessary vitamins and minerals, and that multi-purpose foods now being processed can be made attractive and desirable. On the other hand, Sir Charles Darwin, grandson of the famous evolutionist, is more pessimistic. He believes that the Malthusian relation of too little food for a rapidly growing population will lead to cataclysmic disaster, and that neither technology nor natural sources will provide enough food or fuel for man's needs. However, the English astronomer Fred Hoyle argues against Darwin by minimizing the problems raised; he feels man's ingenuity will meet the situation by determining or limiting populations in some way.

The optimistic note is continued by Harrison Brown, a geochemist, who traces the evolution of the solar system and its planets, and conjectures on the probability of life in the billions of planetary systems in our own and other galaxies. He sees exciting prospects ahead of man learning more of the how and why of his universe, if he can avoid his own destruction.

Lyman Fretwell tells of studies in polar latitudes of cosmic rays that have energies of the order of a billion billion electron volts, as compared with the highest energy particles, five billion electron volts, produced by our largest accelerators.

A form of vegetable life may exist on Mars, according to Frank Salisbury, a plant physiologist, but animal life is not so certain, since it would have to exist in the extremely dry and cold Martian desert. He conjectures that nitrogen, instead of oxygen, would play the active role in energy transfer there.

The Burbidges, Margaret and Geoffrey, write about cosmic alchemy, the creation of the elements in stellar interiors. They discuss stars with light elements, and the red giants with large abundances of heavy elements in their atmospheres or near their surfaces.

The birth, evolution, and death of a star is treated by Allan Sandage. He tells how stars in our immediate neighborhood range in birth date from the beginning of the universe to less than a million years ago, and discusses the determination of age by the rate of the star's exhaustion of energy through nuclear conversion. He theorizes about the birth of a star through the collapse and condensation of a large cloud of gas and dust, with the attendant increase of temperature and density and the consequent nuclear reactions.

Sandage shows color-magnitude diagrams, with stars just at the beginning of their evolutionary life located on the main sequence [see page 17, this issue]. He describes how our sun will evolve in *another* six billion years to where it will have converted 12 per cent of its hydrogen to helium. It will then expand rapidly to about 30 times its present size before it declines in brightness and perhaps becomes a white dwarf.

The editor, Edward Hutchings, Jr., writes about changing ideas on the size and age of the universe. The observational limit with the 200-inch Hale telescope is over one billion light-years, and the estimated age of the universe has been raised from two or three billion to six billion years.

L. A. DuBridge in several essays pleads for new goals; he urges that mathematics be taught more widely so that the layman can comprehend the scientific world. For example, few can grasp the idea of a factor of a million; if we were to count from one to one million at the rate of three numbers a second, it would take nearly four days, counting for 24 hours a day, and to count to a billion would take 10 years.

Ira S. Bowen points out that the value of astronomy is not chiefly in its few direct practical applications, but more in the concept it gives man of his place in the universe.

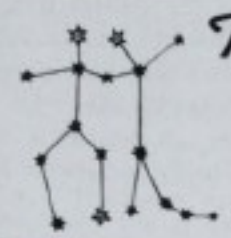
The book is well written, and for the astronomer or for any other scientist, amateur or professional, it affords an opportunity to obtain a bird's-eye view of the accomplishments of his fellow scientists.

LEON E. GOLD
Amateur Astronomers Association
New York 24, N. Y.

THE BLACK CLOUD

Fred Hoyle. Harper and Brothers, New York, 1957. 251 pages. $2.95.

MANY of this magazine's readers think of Fred Hoyle as the most articulate of the new generation of British astrophysicists. It may be a bit dismaying to



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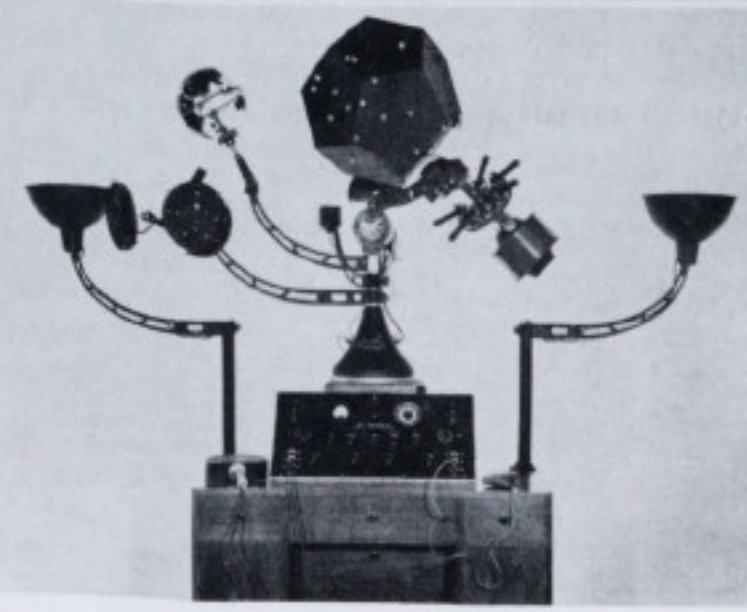

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find the learned exponent of "continuous creation" romping off on a literary lark – he himself calls it a "frolic" – to write this dandy astronomy-fiction mystery thriller complete with attractive girl.

We all know, however, that he has peculiarly strong gifts of expression, and has published books on philosophy and current affairs, in addition to *The Nature of the Universe* and *Frontiers of Astronomy*. And there is a long tradition of serious thinkers using fiction to set forth earnest ideas. Some are now remembered only for their fiction, as is Jonathan Swift and his *Gulliver's Travels*. The fiction of others, like Samuel Johnson and Benjamin Disraeli, is little read today. Finally, Dr. Hoyle had clearly a long list of things he wanted to say, things he had to cast in a form quite different from a report of research findings.

The setting of *The Black Cloud* is pure Palomar Mountain at one end, and England and the Astronomer Royal at the other, with realistic touches that will be appreciated in full by those familiar with astronomy. The time is the near future. After a while the reader will begin to feel the Moonwatch teams might well be alerted to note any odd appearance of a portion of the sky. As the preface states, "After all, there is very little here that could not conceivably happen."

There is unwarranted extrapolation on a magnificent scale, but few will halt at any point in their flight through *The Black Cloud* to say, "This I will not accept." We follow the progress of the cloud and Kingsley, the principal character, with only the breathers a skilled dramatic writer must provide to give added power to the next move.

When we do get a chance to "look around" in the less tense passages, the first question that comes to mind is, "Just how many of these penetrating but harsh opinions of Kingsley are those of Hoyle himself?" It is added mystery to the best cosmic crisis yet concocted.

The Black Cloud tells what Dr. Hoyle was determined to say, related in such a manner that his audience listens to the end.

JOHN W. STREETER
Franklin Institute
Philadelphia 3, Pa.

NEW BOOKS RECEIVED

EXPLORING THE SUN, *Roy A. Gallant*, 1958, *Garden City Books*. 56 pages. $2.50.

Another of Roy Gallant's series for young people, this book uses many large, colored drawings to illustrate ancient beliefs and modern knowledge about the sun.

EXPLORING THE PLANETS, *Roy A. Gallant*, 1958, *Garden City Books*. 123 pages. $2.95.

For young people, this book with its many imaginative illustrations discusses the origin of the solar system and what is known about the planets. It gives tables showing the positions of the five brightest planets for the next 11 years.

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for Radio Astronomers and Communications Engineers

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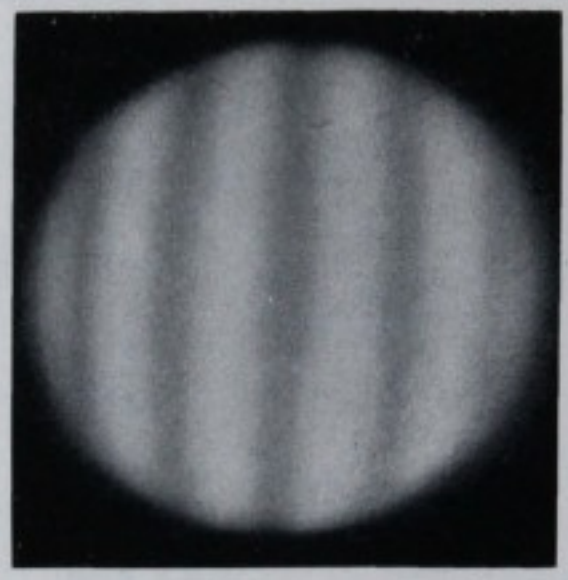

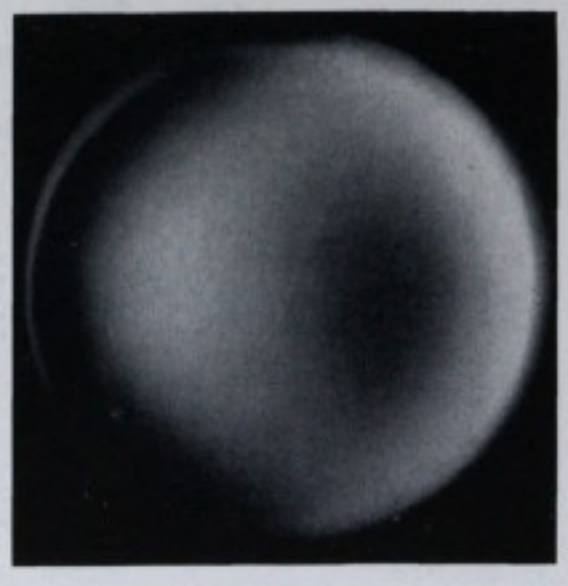

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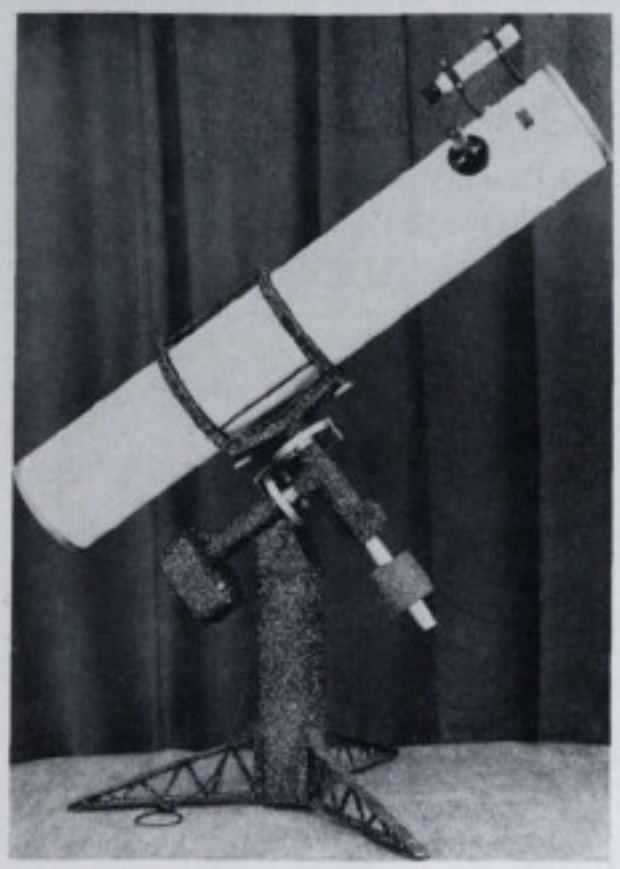

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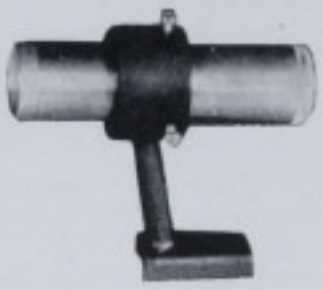

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Balancing the Tube of a Reflecting Telescope

AMONG amateur-built reflectors, statically unbalanced instruments are the rule rather than the exception. While friction in the bearings or restraining clamps on the axles often conceal a lack of equilibrium, such a condition cannot be tolerated if slow-motion controls are to work properly or if a driving clock is to be added.

Recently, this department received a communication from Dr. George Van Biesbroeck, well-known astronomer at Yerkes and McDonald Observatories, in

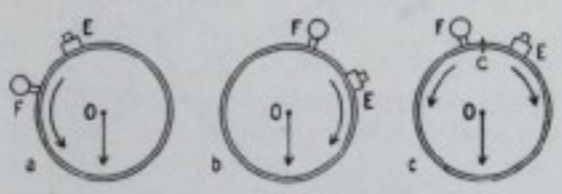

Fig. 1. Conditions of unbalance, the telescope tube tending to rotate one way or the other, except when oriented as in drawing c. Gravity is in the direction of the vertical arrow.

which he describes the procedures for making the final adjustments to balance a telescope in all positions. But before presenting his suggestions (in a subsequent article), it is necessary to discuss the steps an amateur should take to balance the reflecting telescope tube and its attachments around the optical axis. If a rotating tube is planned, it would be impossible to overcome the effects of gravity in all positions of the telescope if such balance were not achieved at the very beginning.

In most reflectors, the mirror and its cell are symmetrical about the optical axis, and diagonal supports are usually symmetrical also. But every instrument must have an eyepiece base mount, with the adapter tube and eyepiece itself, all represented by E in Fig. 1. If there is a finder, it will probably be mounted at least 45 degrees from the eyepiece, as shown by F. Obviously, these cause a tendency for the tube to rotate one way or the other, as shown in Fig. 1a and 1b; only in a special position, 1c, will E and F tend to balance each other. How can we obtain an equilibrium condition for all orientations of E and F with respect to the optical axis?

Our example will be the tube shown schematically in Fig. 2, with a diameter of 8″ and a three-pound finder whose center of gravity is 7″ from the optical axis. The two-pound eyepiece assembly has its center of gravity 5″ from the optical axis. As in Fig. 1, the angle EOF is 45°, and the direction of gravity is indicated by the arrow pointing downward just below the center O.

In order to compute the moments of force of E and F around O, we first assume a particular orientation of the tube. In this example, we take angle P′OE as 30°, which makes P′OF 75°, since angle EOF has been set at 45°. The construction lines of Fig. 2 show how to compute the moments, which act as if the weights of E and F were located at E′ and F′, on the horizontal line PP′. We shall denote the weights of E and F by E and F, respectively. The moment of E is E multiplied by the distance OE′, while that of F is F times OF′. The numerical results are shown in the diagram.

We will attempt to cure the rotational tendency by placing a counterweight W at a distance of 6″ from the optical axis, somewhere on the opposite side of the tube from E and F, as indicated by the

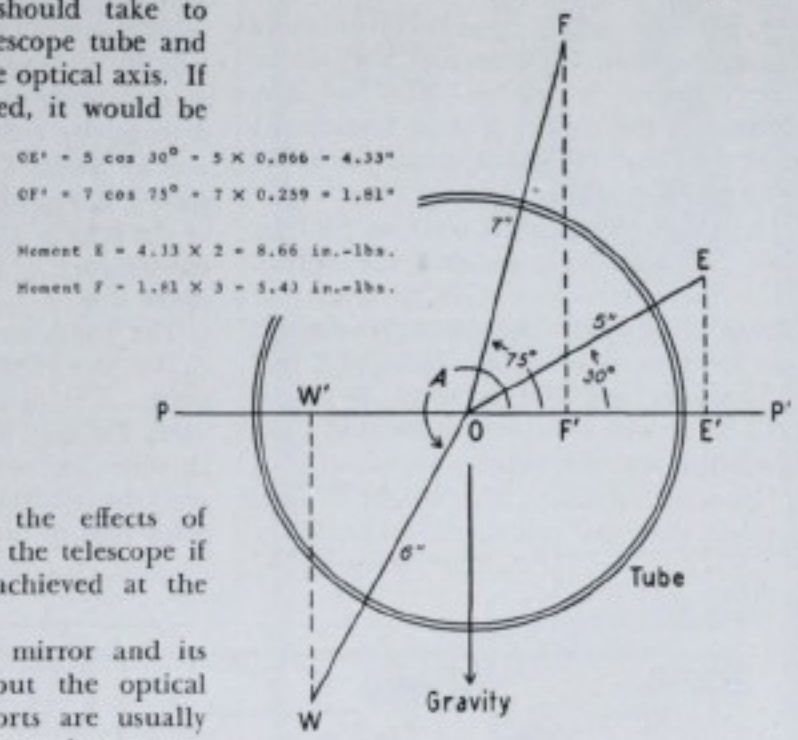

Fig. 2. In order to evaluate the angle A and to determine the amount of counterweight required, an arbitrary position of the tube is assumed. In Fig. 3, another position is chosen to permit setting up a second equation of equilibrium.

angle A. The moment of W is $6\,W \cos A$. Equilibrium requires that the sum of the moments of E, F, and W shall be zero:

$$8.66 + 5.43 + 6\,W \cos A = 0,$$

or

$$6\,W \cos A = -14.09. \qquad (1)$$

But in this formula we have two unknowns, the weight W and the angle of orientation A. Therefore, in accordance with well-known algebraic rules, we need another independent equation, which can be derived by considering another position of the telescope tube.

Therefore, in Fig. 3 the whole system

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has been rotated counterclockwise through 90°, placing E and F on the other side of the tube. A change of this kind commonly occurs when a rotating tube is used for ease in observing. In this position, the moments are different, the numerical values being given in the diagram. The equilibrium condition for Fig. 3 is:

$$-5.00 - 20.29 + 6\,W\,(-\sin A) = 0$$

or

$$6\,W \sin A = -25.29. \quad (2)$$

This condition is to be satisfied simultaneously with that of Equation 1. One method of solving these equations is to divide one by the other:

$$\frac{6\,W \sin A}{6\,W \cos A} = \tan A = \frac{-25.29}{-14.09} = 1.796.$$

Therefore A, which must be in the third quadrant since both its sine and cosine are negative, is 240°.9. Now we may substitute the cosine of A in Equation 1 and solve for W, which comes out to be 4.83 pounds.

As a check that in any position the tube will be in balance around the optical axis, the reader may wish to place the assembly in a new position and compute the moment of W against those of E and F. In some positions, however, W and E will be on one side of the tube and F on the other, and vice versa.

In actual practice, the weight W will be less than the calculated value, for it is necessary to take into account the weight of the supports that hold it to the tube. Furthermore, as far as equilibrium around the optical axis is concerned, W need not be at the top (eyepiece) end of a Newtonian reflector directly opposite E and F, although many amateurs prefer it there. It can be placed anywhere along the side of the tube on a line through W parallel to the optical axis. This permits using the counterweight to stabilize the tube around the declination axis, which is the next step in the balancing process.

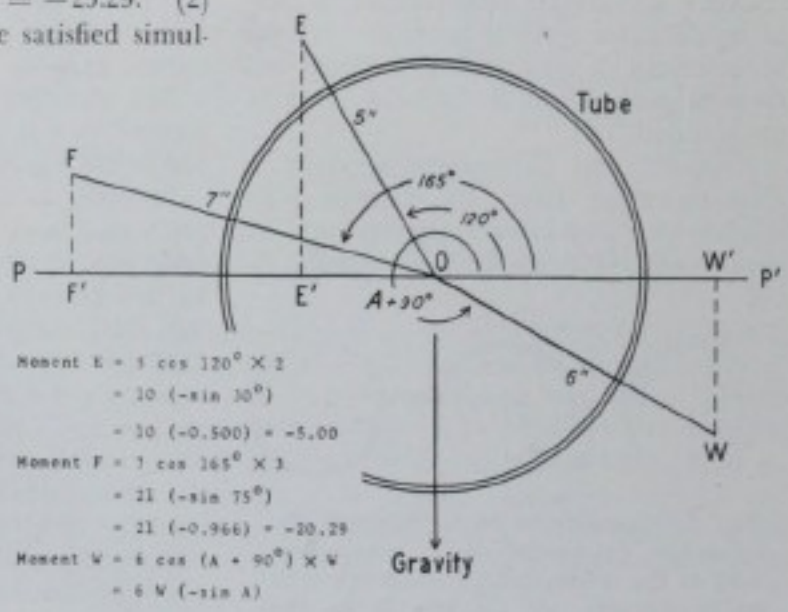

Fig. 3. Here the orientation of the tube has been changed 90 degrees in a counterclockwise direction, compared to the position in Fig. 2. Solving the equations of equilibrium based on these two situations gives the required angle A and the amount of counterweighting used.

Fig. 4 shows the general problem, in which the following components are indicated: eyepiece E, finder F, spider support and diagonal S, counterweight W, mirror and cell M, position of declination axis D. With respect to D, these parts are at the distances (along the optical axis) denoted by e for eyepiece, f for finder, and so forth. The over-all length of the tube is t, and the weight per unit length of the tube is T. The symbol x stands for the distance of D from the eyepiece end of the tube.

The condition for equilibrium is stated by the expression given in the diagram. The first moment is of the tube itself, for that part on the mirror side of D, where the weight is given by $T(t - x)$ and the distance by $\frac{1}{2}(t - x)$. For the other part of the tube, the moment is Tx

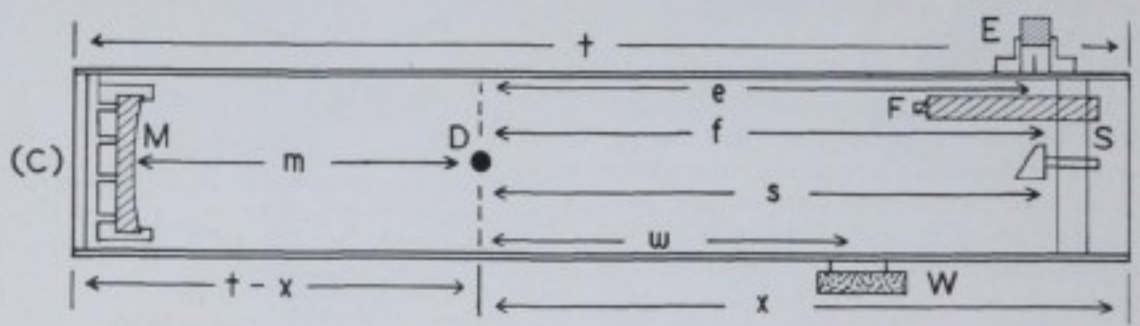

Fig. 4. On the assumption that balance around the optical axis has first been achieved, the distances from the declination axis, D, to the various components may be measured as if they were located on the optical axis. For illustration purposes, the parts are pictured as if they were in the same plane. The basic formula for a condition of static balance around D is on the first line below the diagram; the second line gives a convenient working form of this formula.

times $\frac{1}{2}x$. The expression reduces to the form:

$$\tfrac{1}{2}Tt^2 - Ttx + Mm = Ee + Ff + Ss + Ww, \quad (3)$$

and from this general equation many arrangements may be computed, according to the needs of the telescope design.

A number of special cases are worth considering:

Case 1. Point D is centered at the midpoint of the telescope tube. Here $x = \frac{1}{2}t$, and $\frac{1}{2}Tt^2 - Ttx = 0$. Hence,

$$Mm = Ee + Ff + Ss + Ww. \quad (4)$$

If w comes out with a negative sign, the location of the counterweight is to the left of D, on the mirror end of the tube.

Case 2. The counterweight W is placed at the same distance from D as the eyepiece is. Equation 4 becomes

$$\tfrac{1}{2}Tt^2 - Ttx + Mm = e(E + W) + Ff + Ss. \quad (5)$$

If the mirror is relatively light, this construction will require a shift of the declination-axis position toward the eyepiece end of the tube.

Case 3. A combination of Case 1 and Case 2, in which D is at the tube's midpoint while W and E are at the same distance, e. In this case it is probable that an additional counterweight, C, will have to be added at the mirror end. As in Case 1, $x = \frac{1}{2}t$, and $\frac{1}{2}Tt^2 - Ttx = 0$. Therefore, we write

$$Cc + Mm = e(E + W) + Ff + Ss, \quad (6)$$

and the value of C will depend on the choice of the distance c between C and D.

Case 4. For a fork mounting, D may be placed one-third of the tube length from the mirror end. Here $x = \frac{2}{3}t$, and $\frac{1}{2}Tt^2 - Ttx = -\frac{1}{6}Tt^2$. Therefore

$$Mm - \tfrac{1}{6}Tt^2 = Ee + Ff + Ss + Ww. \quad (7)$$

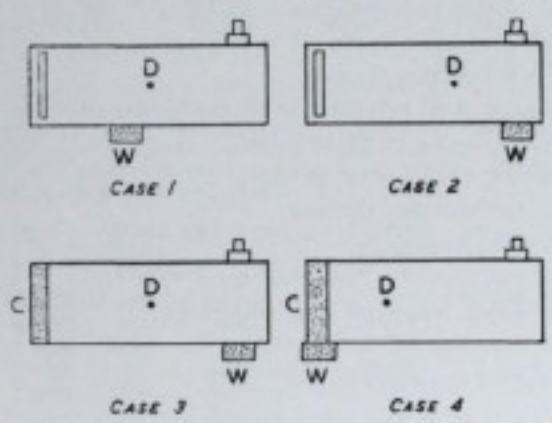

Fig. 5. The relative locations of D, W, and C in the four examples that are worked out in the text.

Numerical Examples

To illustrate the use of these formulas, let us adopt the following values:

$M = 4$, $E = 2$, $F = 3$, $S = 1$, $W = 4.8$ lbs. $t = 48''$; $T = 0.15$ lb. per inch; $Tt = 7.2$. $m = t - x - 2$; $e = x - 4$; $f = x - 6$; $s = x - 3$.

Case 1. In this simple arrangement, with the declination axis in the center of the tube longitudinally, we can actually ignore the weight of the tube itself, as it

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is equally divided on each side of D. Since $x = 24$, Equation 4 becomes:

$$88 = 40 + 54 + 21 + 4.8w$$
$$w = -5.625.$$

The counterweight will have to be placed $5\frac{5}{8}$ inches from D toward the mirror end.

Case 2. Suppose it is desired to have W located approximately opposite the eyepiece at the upper end of the tube, making $w = e$. Where should the tube be supported? Using Equation 5, we have

$$172.8 - 7.2x + 184 - 4x = 10.8x - 48.2$$
$$x = 405/22 = 18.41,$$

which places D about $18\frac{1}{2}$″ from the eyepiece end of the tube and about $29\frac{1}{2}$″ from the mirror end.

Case 3. Since $x = 24$, Equation 6 gives

$$Cc + 88 = 259.2 - 48.2$$
$$Cc = 123.$$

This is the unbalanced moment at the mirror end, which could be compensated by a weight of over five pounds at the extreme end of the tube, 24 inches from D. However, a single weight would destroy the balance around the optical axis. To prevent this, we might divide the balancing weight in half, placing the halves diametrically opposite each other. Another way would be to fit a ring around the tube, making its weight six pounds and placing it about 16″ from the centered position of D. Some amateurs prefer a weight under the mirror cell, where it can be symmetrically placed around the optical axis and where it requires the least weight because it is farthest from D.

Case 4. For a fork-type mounting, the clearance of the mirror end in the fork determines the position of the declination axle. We have already assumed the support point to be two-thirds of the way from the upper (eyepiece) end. We use Equation 7 to find

$$56 - 57.6 = 56 + 78 + 29 + 4.8w$$
$$4.8w = -164.6$$
$$w = -34.3.$$

Counterweight W would have to be placed more than 34″ to the left of D if it alone had to balance the tube. This position is obviously impossible, but if W were placed 16″ from D, at the extreme mirror end of the tube, its moment would be only 76.8 inch-pounds. Another counterweight is necessary, and if it were at the extreme end, its weight would be about $5\frac{1}{2}$ pounds, to furnish the additional moment of 87.8 inch-pounds. A better solution might be a ring counterweight, weighing about six pounds and placed 2″ from the mirror end of the tube. In whatever way W and C are combined, they must provide a total moment of 164.6 inch-pounds. R. E. C.

CORRECTION

On page 652 of the October issue, in the ninth line of the middle column, for $1\frac{1}{2}$″ read $1\frac{1}{4}$″.

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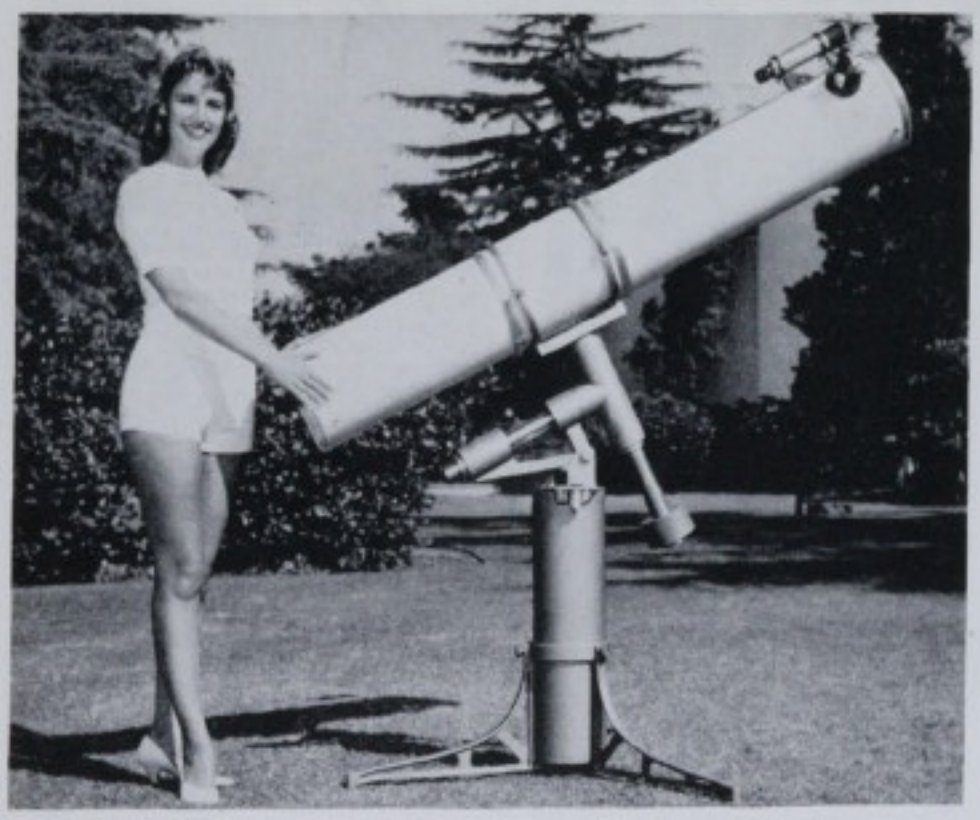

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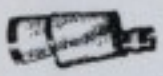
20 x 50	183	"Zeiss"	41.50	39.50

MONOCULARS



Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
6 x 30	$10.00	7 x 50	$14.75
8 x 30	11.25	16 x 50	17.50
7 x 35	12.50	20 x 50	20.00

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 30 days.

NEW! 6" LENSES

Our 6" objective will not need high-pressure salesmanship. Its sparkling performance speaks for itself. Test one, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee.

6" DIAM. AIR-SPACED TELESCOPE OBJECTIVE

Hard coated on 4 surfaces

f/10 - 60" focal length { MOUNTED ..... $175.00 ; UNMOUNTED 150.00

f/15 - 90" focal length { MOUNTED ..... 175.00 ; UNMOUNTED 150.00

We can supply ALUMINUM TUBING for the lenses above.

"GIANT" WIDE ANGLE EYEPIECES

ERFLE EYEPIECE (65° field) contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Will make an excellent 35-mm. Kodachrome Viewer. Magnifies seven times ..... **$12.50 ppd.**

Same as above without diopter scale **$9.95**

WIDE ANGLE ERFLE (68° Field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1-13/16" aperture **$13.50**

WIDE ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field **$12.50**

1¼" Diam. Adapter for Erfle eyepieces **$3.95**

SPECIAL COATED OBJECTIVE BIG 2⅛" DIAM. — 40" F.L. — $6.00

These achromatic objective lenses are tested and have the same high quality as "Big Lenses" described at left, except they are seconds for slight edge chips or small scratches only. Quality guaranteed.

ONLY $6.00 ppd.

ASTRONOMICAL MIRRORS

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon-monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	$ 9.75
Pyrex	4¼"	45"	13.50
Pyrex	6"	60"	25.00

MIRROR MOUNTS, RACK-AND-PINION ● EYEPIECE MOUNTS, and ALUMINUM TUBING are available.

90° RIGHT-ANGLE PRISMS

8-mm. face	$1.00		
12-mm. face	1.00		
23-mm. face	1.25	Silvered	$2.00
28-mm. face	1.75	Silvered	2.50
38-mm. face	2.00	Silvered	2.75
48-mm. face	3.00	Silvered	4.00
62-mm. face, coated	$17.50		

TELEVISION PROJECTION LENS

Brand New. f/1.9, E.F.L. 5 inches. Manufactured by Bausch & Lomb. We purchased entire lot of these discontinued units. Five elements, smallest lens 2", largest 4⅛". Completely assembled 6" in length. All surfaces hard coated. Get this BARGAIN now.

ONLY $22.50

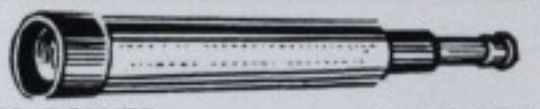
MOUNTED EYEPIECES

The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
6 mm. (¼")	Ramsden	$ 4.75
12.5 mm. (½")	Ramsden	4.50
12.5 mm. (½")	Symmetrical	6.00
16 mm. (⅝")	Erfle (wide angle)	12.50
16 mm. (⅝")	Triplet	12.50
18 mm. (¾")	Symmetrical	6.00
22 mm. (27/32")	Kellner	6.00
27 mm. (1-1/16")	Kellner	4.50
32 mm. (1¼")	Orthoscopic	12.50
35 mm. (1⅜")	Symmetrical	8.00
55 mm. (2-3/16")	Kellner	6.00
56 mm. (2¼")	Symmetrical	6.00

COATED LENSES 75 cents extra.

GIANT "3" inch TELESCOPE



40 POWER postpaid **$57.50**

HIGH-POWER SPOTTING SCOPE — American Made. Big 3"-diameter achromatic coated objective will give bright crystal-clear images. Micrometer spiral focusing drawtube. Lightweight aluminum construction throughout, black crackle finish, length open 22", closed 15½". Upright image. Guaranteed to give superb performance.

8-POWER ELBOW TELESCOPE

This M-17 telescope has a brilliant-image 48° apparent field — 325 feet at 1,000 yards. The telescope can be adjusted for focusing 15 feet to infinity. It has a 2" objective, focusing eyepiece 28-mm. focal length with an Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

8 x 50

BARGAIN PRICE ... **$13.50 ppd.**

A. JAEGERS

6918 Merrick Road LYNBROOK, N. Y.

JUST REDUCED!

SATELLITE TELESCOPE

In setting the original price of our Satellite Telescope we figured amortization of tooling and engineering over 1,000 scopes. While sales haven't reached this point, because so many made their own instruments by using our unmounted optics, we have decided to take our loss on tool amortization and reduce the price. It's still the best satellite telescope available, so get yours now! Especially made for members of MOONWATCH. Gives you the greatest possible field with the ability to observe faint objects with only slight magnification. Wide (51-mm.) diameter, low-reflection-coated objective lens. A 6-element, extremely wide field, coated Erfle eyepiece, which in combination with the objective gives 5.5 power with a big 12° field and over 7-mm. exit pupil. This scope also makes a perfect wide-field finder — a wonderful comet seeker; see complete asterisms with it.

Stock #70,074-Y.....$39.50 ppd.

Take Photos of the MOON Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

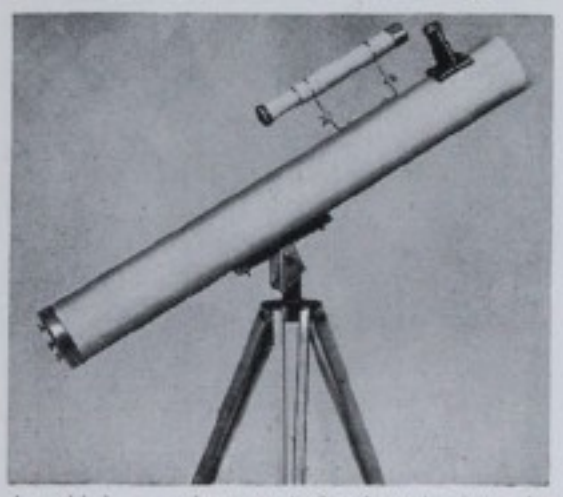
Includes brackets, 28¼" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

Stock #70,162-Y.....$9.95 ppd.

Send check or money order — Money-back guarantee.

3" ASTRONOMICAL REFLECTOR

60 to 160 Power — An Unusual Buy!



Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y.....$29.95 ppd.

TELESCOPE CAMERA

Here is a special camera for taking excellent closeup shots through your telescope — pictures of the moon, stars . . . terrestrial telephoto pictures. Sturdily built, easily operated, this useful camera employs sheet film. One film holder, size 2¼" x 3¼", is included. Camera lens is 4-element — not only magnifies the image but extends it from normal eyepiece image plane to film plane. Yellow filter included. Camera box size is 3" x 4" x 5". Tube that fits into eyepiece holder is 5" long with 1¼" O.D. for standard telescopes. Cable release and 3¼"-x-4½" piece of ground glass for focusing also included. Precision German-made shutter has settings for Time, Bulb, 1, ½, 1/5, 1/10, 1/25, 1/100, and 1/200 second. Also has delayed-action shutter release.

Stock #70,166-Y.....$39.50 ppd.

REPLICA GRATING Low, Low Cost

It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch, running long way on film 8" wide — grating area 7½". Thickness about 0.005". Dispersion about 24° in 1st order. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear-plastic protector.

Stock #40,267-Y....8" by 11" piece.....$1.50 ppd.
Stock #50,180-Y....8" by 6' piece.....$5.95 ppd.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y....¼" focal length....$4.75 ppd.
Stock #30,203-Y....½" focal length....$4.50 ppd.

OBSERVE SUNSPOTS

Reduce intensity of the sun's rays, by using a Herschel wedge plus a sun filter over the eyepiece.

UNMOUNTED HERSCHEL WEDGE

Size, 40 mm. x 55 mm.; wedge angle is 10°. The critical surface is flat to ¼ wave. Not mounted.

Stock #30,265-Y.....$3.50

MOUNTED HERSCHEL WEDGE

Same size as above but mounted with diagonal holder for reflectors. Fits our rack-and-pinion holder, Stock No. 50,077-Y, that is also used on our 4¼" and 6" reflectors. Holder rod is long enough for 4¼", 6", and 8" mirrors. Rod is 5/32" diameter and 5" long.

Stock #30,266-Y....$5.50

INVITATION

VISIT OUR RETAIL STORE — (10 miles from Philadelphia — two miles from Exit #3 of the New Jersey Turnpike). When you're near us, stop in and see our big display. Our store contains many miscellaneous items at bargain prices.

K-24 AERIAL CAMERA

War surplus. New or near new — guaranteed perfect working order. Excellent camera for photographing satellites. Complete with 7" f/2.5 Kodak Aero Ektar lens and magazine which takes film 5½" wide x 26' long.

Stock #85,067-Y.....$99.50 f.o.b. Utah

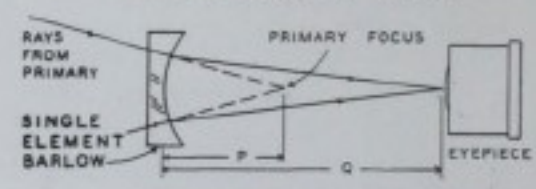
AERIAL CAMERA LENS

f/2.5 with 7" Focal Length

An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

Stock #70,161-Y.....$39.95 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....$7.95 ppd.

EDMUND SCIENTIFIC CO.

Sale! Terrific Bargains!

WAR-SURPLUS AERIAL CAMERA LENSES

24" Focal Length, f/6, in 23"-long Lens Cone

Made by Bausch & Lomb and Eastman Kodak

$39.50, Used; $59.50, New; Gov't. Cost $1,218.00

Mounted in beautiful brass cells, lenses are 4"-diameter precision 4-element type. Aero Tessar and Aero Ektar (no choice). Housed in cone — focal plane 10" beyond cone and permits attaching a film holder, eyepiece, or the like. Lenses are easily removed for other uses. Diaphragm is included — adjusts by flexible rod (easily extended) from f/6 to f/22; opens approximately 1" to 3½". Weight of lens and cone 25 lbs. Sturdy carrying trunk weighs 26 lbs.

USES: 1. For use as long-range, Big Bertha telephoto lens. 2. For richest field (wide field, low power) telescope. 3. As opaque projector lens. 4. For use in operation PHOTO-TRACK (photographing artificial satellites).

SALE AERIAL CAMERA LENSES

Lens Cones with f/6 24" focal length —

Stock #85,059-Y....24", Used.....$39.50 f.o.b. Utah

Stock #85,060-Y....24", New.....$59.50 f.o.b. Utah

ALSO AVAILABLE

Lens Cones with f/8 40" focal length —

Stock #85,061-Y.....Used.....$68.50 f.o.b. Utah

Stock #85,062-Y.....New.....$89.50 f.o.b. Utah

TRULY AMAZING BARGAIN — MECHANICAL DRAWING SET

Regular Price, $18.00 — Our Price, Only $6.00 ppd.

10 handsome pieces in velvet-lined case. Bows have center wheels; dividers are 5¼" long. Instruments are nickel-plated brass, precision American made. Set contains 5½" Swedish ruling pen, 5½" compass, lengthening bar for compass 3¾", interchangeable pen for compass, 5½" dividers with straightening device, center-wheel 3" bow pen, center-wheel 3" bow pencil, center-wheel 3" bow divider, adjusting screwdriver, spare-parts container with leads and points. We guarantee you will be satisfied or your money refunded.

Stock #50,200-Y.....$6.00 ppd.

Quantity prices: 5 sets for $5.50 each ppd.
10 sets for $5.00 each ppd.

Rack & Pinion Eyepiece Mounts

For Reflectors

Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $8.50 ppd.
Stock #60,049-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

5" DIAM. TELESCOPE OBJECTIVE AIR-SPACED ACHROMAT

Coated 4 surfaces. Focal length 71", f/14.2. Effective aperture f/15, 4.73".

Stock #70,163-Y...Unmounted.....$125.00 ppd.

Stock #70,164-Y...Mounted in cell (inside diam. 5"; outside diam. 5½" with 6½" flange) with adapter to fit 6⅞" I.D. tubing.....$150.00 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

STANDARD 1¼" EYEPIECE HOLDER

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....$2.50 ppd.

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

"TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

Stock #9054-Y.....60c ppd.

OTHER USEFUL BOOKLETS

"OBSERVING THE SUN"
Stock #9056-Y.....15c ppd.

"TELESCOPE FINDERS"
Stock #9051-Y.....15c ppd.

Sale! GIANT ERFLE EYEPIECE

Here is an exciting bargain. We just bought a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this sale is over, and triple and quadruple as years pass. If we didn't owe the bank so much money, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

Stock #50,178-Y.....Sale Price $9.95 ppd.

3X ELBOW TELESCOPE

Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Although our price has been only $7.40 postpaid, they just sit on our shelves year after year. Then to get an item we really wanted, we had to buy 200 more of these telescopes recently. Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm. At our new price we cannot afford to have our instrument man take these apart and clean them — so we told him to look them over to make sure everything is okay, and now you can buy them for only $5.00 each delivered to you.

Stock #50,179-Y.....$5.00 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

MIRROR STAR DIAGONAL

For comfortably viewing astronomical objects with refracting telescopes — also excellent for finders on reflecting telescopes. Can be used on standard microscopes as it is correct size. Eyepiece end takes oculars with 0.917" O.D. and objective end fits into tubes with 0.917" I.D. Made of fine plastic, and contains a first-surface mirror.

Stock #30,278-Y.....$3.00 ppd.

7X FINDER TELESCOPE—ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95

Stock #50,075-Y Ring mounts per pair.....$3.95

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

Satellite Observers

Here is an extremely fine, imported Zuiho binocular, just the thing for satellite observing. Note the wide field of view — 10.5°!

Delivered anywhere in the Continental United States.

Complete with beautiful case **$35.00** TAX PAID

AMERICAN TYPE WIDE ANGLE
7 x 35 Central Focus

SPECIFICATIONS —

Magnification	7x
Objective aperture	35 mm.
Eyepiece aperture	24 mm.
Diameter of exit pupil	5 mm.
Field of view at 1,000 yards	551 feet
Field-of-view angle	10.5°
Height	128 mm.
Breadth	195 mm.
Net weight	950 grams
Weight of pigskin case	400 grams

We have sold hundreds of pairs of these binoculars with the utmost satisfaction. Remember, they are unconditionally guaranteed. If you are not pleased with them, send them back to us and your money will be immediately refunded.

Before you buy or trade a telescope or radio amateur gear, see WARD W2FEU for the best deal.

ADIRONDACK RADIO SUPPLY

Established 1936

P. O. BOX 88

AMSTERDAM, NEW YORK

Ward J. Hinkle, W2FEU — Owner

CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

VARIABLE STAR MAXIMA

November 1, S Ursae Majoris, 123961, 7.9; 7, R Virginis, 123307, 6.9; 9, R Phoenicis, 235150, 7.8; 17, T Columbae, 051533, 7.6; 18, S Canis Minoris, 072708, 7.5; 22, T Cassiopeiae, 001755, 7.8; 30, R Leonis Minoris, 093934, 7.2; 30, V Bootis, 142539, 7.9.

December 7, T Centauri, 133633, 6.1; 16, T Herculis, 180531, 8.0; 20, R Ursae Majoris, 103769, 7.6.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

NOVEMBER METEORS

Two weak meteor showers are observable this month, neither of which will be seriously masked by moonlight. The Taurids reach maximum during the first seven days of November, when a single observer may see up to 12 meteors per hour, including sporadic ones. The Leonids come during the morning hours of November 16-17. If sky conditions are favorable, 15 to 20 meteors per hour may be visible before dawn, according to P. M. Millman, but a much lower hourly rate is cited by H. B. Ridley in the 1958 *Handbook* of the British Astronomical Association. W. H. G.

MINOR PLANET PREDICTIONS

Amphitrite, 29, 8.7. October 24, 3:36.5 +27-18. November 3, 3:27.8 +27-24; 13, 3:17.4 +27-13; 23, 3:06.8 +26-48. December 3, 2:57.5 +26-14; 13, 2:50.7 +25-38. Opposition on November 14.

Flora, 8, 7.9. October 24, 4:02.1 +9-45. November 3, 3:55.4 +9-21; 13, 3:46.0 +9-05; 23, 3:35.5 +9-03. December 3, 3:25.9 +9-18; 13, 3:18.8 +9-53. Opposition on November 19.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

November 1, 13:39; 4, 10:27; 7, 7:16; 10, 4:05; 13, 0:54; 15, 21:43; 18, 18:32; 21, 15:21; 24, 12:10; 27, 8:59; 30, 5:48.

December 3, 2:37; 5, 23:26; 8, 20:15.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

SKY-GAZERS EXCHANGE

Classified advertising costs 30 cents a word, including address; minimum charge, $4.00 per ad. Only one *for sale* ad per issue for each advertiser. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., *Sky and Telescope,* Harvard Observatory, Cambridge 38, Massachusetts.

EQUATORIAL MOUNTS: Four sizes, $21.95 to $74.95. Free literature. Marvin Stell, 600 E. 5th, Coleman, Tex.

TELESCOPE TUBING: Aluminum, 2" through 8" diameter, any length. Pesco-A, Box 363, Ann Arbor, Mich.

STAR MAPS: Find over 90 galaxies, globular and open clusters, nebulae, double and variable stars, with your telescope. Shows major constellations down through 4th magnitude and to −40°. Printed on cardboard, with detailed descriptions in observer's guide. $1.00 for 4 maps and guide. Joseph Mickel, 1307 Ridgelake, Metairie, La.

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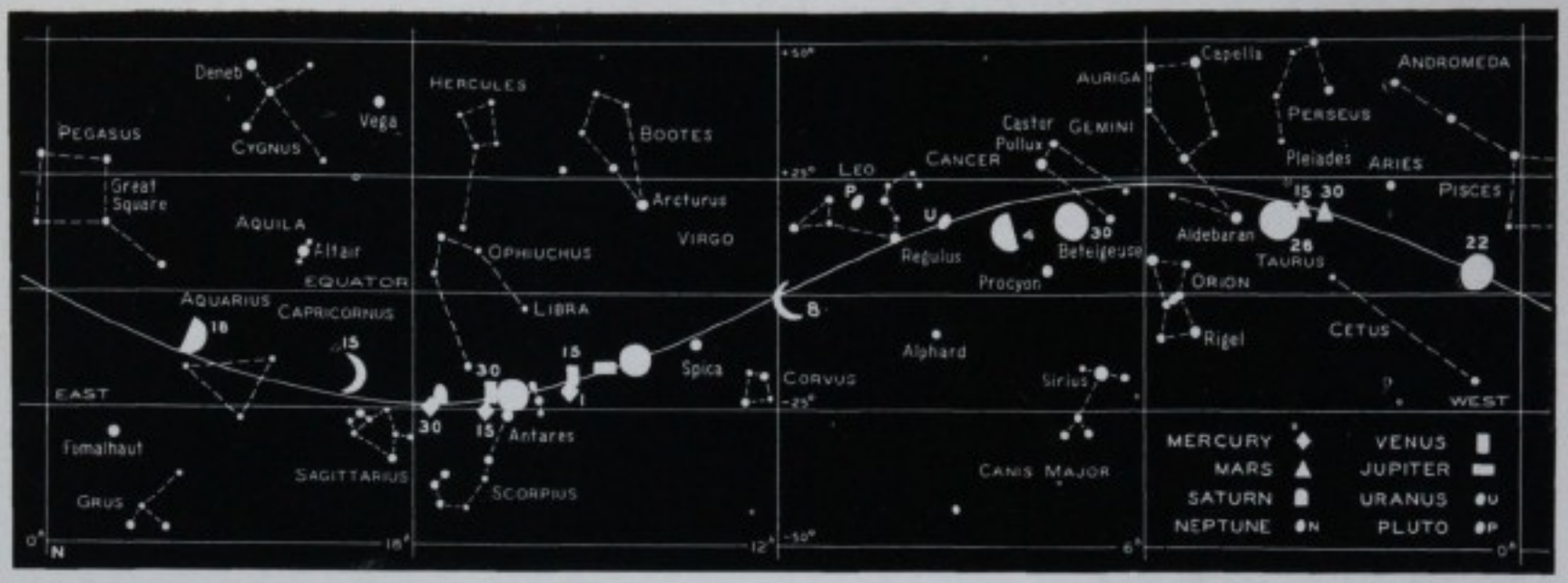

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury is an evening star throughout November, reaching greatest eastern elongation on the 20th, 22° 13′ from the sun. This is not a favorable elongation, but during the last half of November the planet may be seen during early twilight, low in the southwest and of magnitude −0.1, setting an hour after the sun.

Venus reaches superior conjunction with the sun on the 11th, passing from the morning to the evening sky, but all month it will be too close to the sun to be seen.

Mars is the dominating planet in the nighttime sky, well situated at a high northerly declination in western Taurus, where it rises about sunset and remains visible all night. This is the month of opposition, which occurs on November 16th, but closest approach to the earth occurs on the 8th, when Mars will be only 45.4 million miles distant. Telescopically, the planet will appear as a reddish disk 19″ in diameter.

Mars' magnitude is −1.8 on November 1st, −2.0 on the 15th, and −1.6 on the 30th; the planet will be roughly 10 times as bright as nearby Aldebaran, a reddish star of the 1st magnitude. The moon and Mars will make a fine sight during the night of November 24-25, when the moon passes about 3° south of the planet.

Jupiter is in conjunction with the sun on November 5th, and lost in its glare.

Saturn can be seen low in the southwest on the Ophiuchus-Sagittarius border, setting about two hours after the sun in the middle of the month.

Uranus will reach western quadrature on November 9th, rising slightly before midnight. On the 15th its apparent right ascension is 9^h 16^m.0, declination +16° 35′. On the 22nd, this 6th-magnitude planet will be stationary in right ascension, beginning its slow retrograde (westerly) motion among the stars.

Neptune is an 8th-magnitude object in Virgo west of Jupiter, and not observable this month.

Artificial satellite observations in November may be made with the help of a star chart from an October issue for evening twilight, from an April issue for morning.

W. H. G.

MOON PHASES AND DISTANCE

Last quarter	November	4, 14:19
New moon	November	11, 6:34
First quarter	November	18, 4:59
Full moon	November	26, 10:16
Last quarter	December	4, 1:24

November		**Distance**	**Diameter**
Perigee	10, 14^h	222,300 mi.	33′ 24″
Apogee	23, 5^h	252,200 mi.	29′ 27″
December			
Perigee	9, 0^h	224,600 mi.	33′ 04″

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

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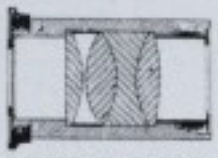

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STARS FOR NOVEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of November, respectively; also, at 7 p.m. and 6 p.m. on December 7th and 23rd. For other dates, add or subtract ½ hour per week.

The eastern side of the Great Square of Pegasus, near the meridian now, points southward toward Deneb Kaitos, in Cetus. Much farther south is bright Achernar, just above the horizon for observers at latitude 30° north. The western side of the Great Square points to Fomalhaut.

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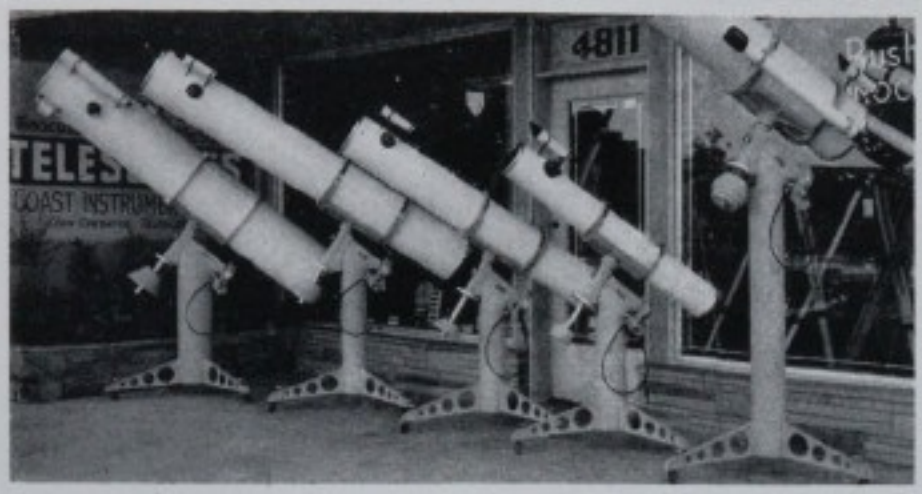

TRECKERSCOPES (from left to right) — 12½" DE LUXE, 10" DE LUXE, 8" DE LUXE, 6" DE LUXE, and 10" CASSEGRAIN "SKY-GIANT"

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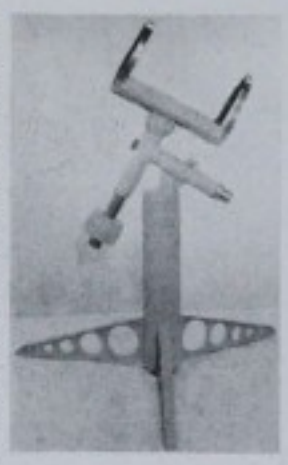

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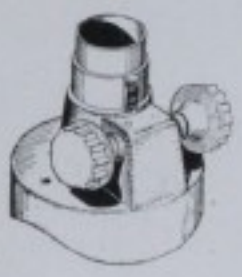

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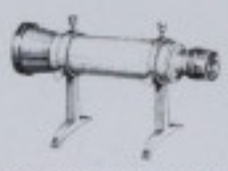

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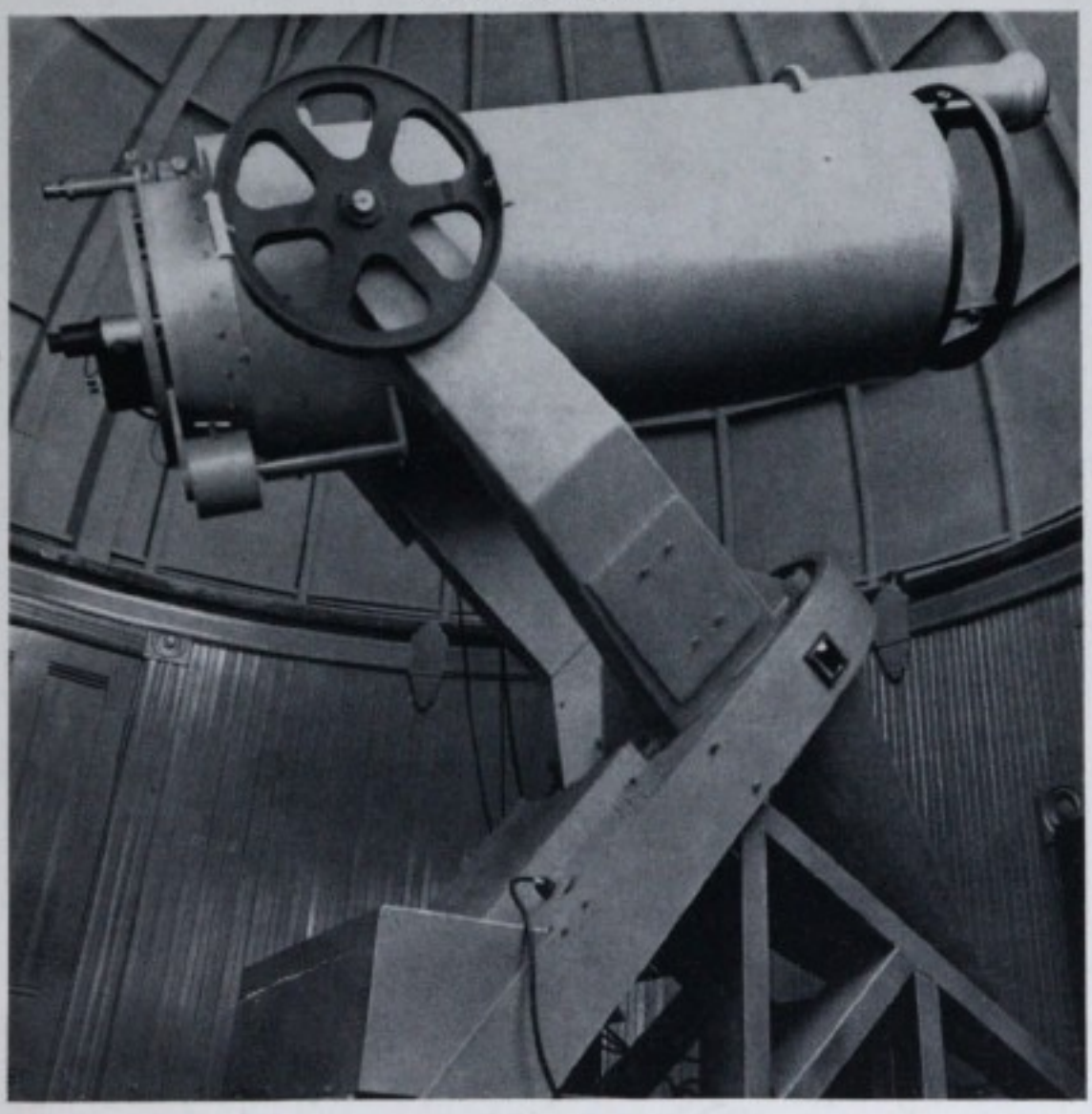

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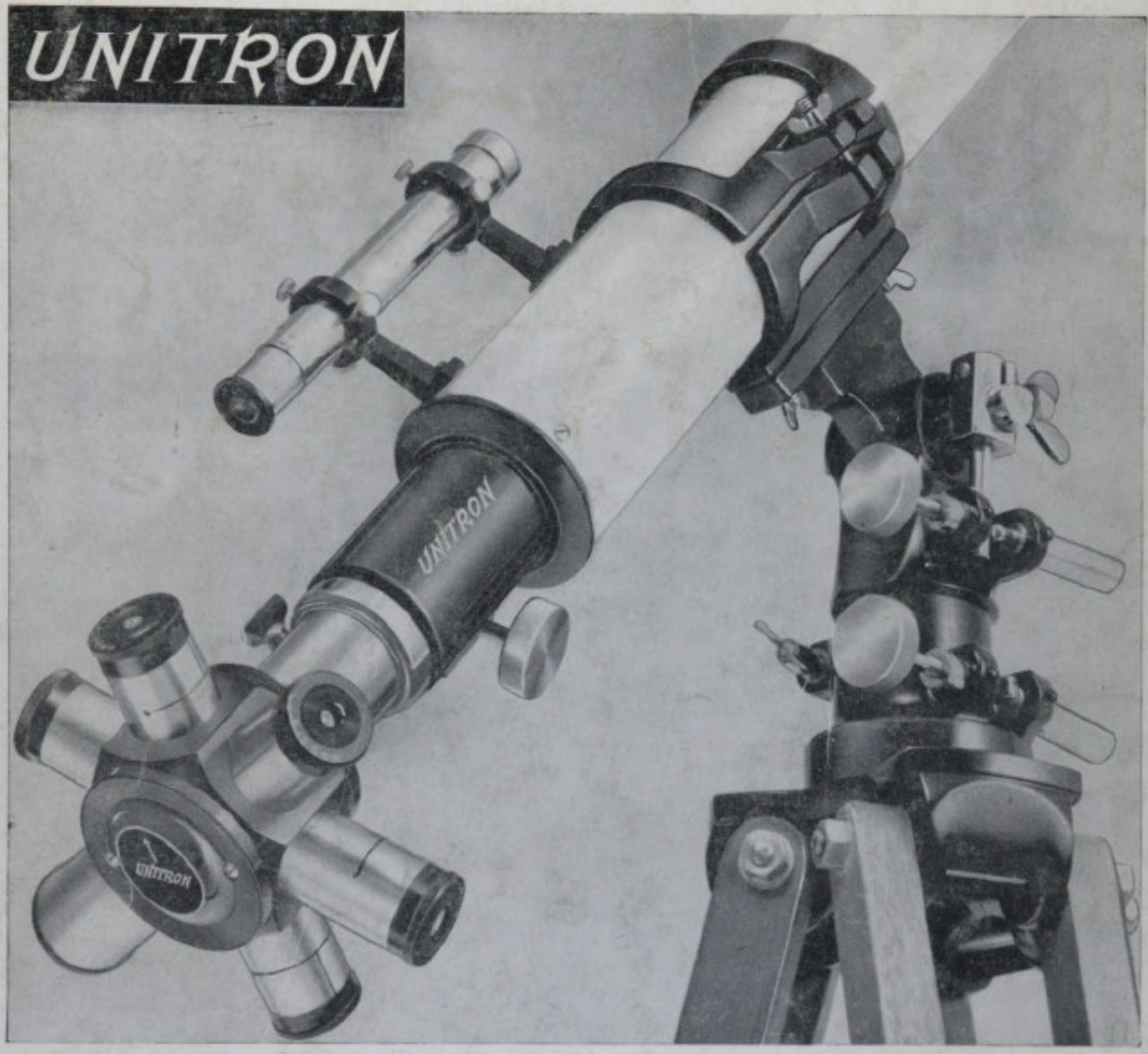

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